Appendix A –

Definitions

Appendix A - Definitions

The following definitions are provided for reference and use with this manual. **All projects must also refer to the definitions section of the Stormwater Code (SMC Chapter 22.801). Where any inconsistencies exist between this appendix and SMC Chapter 22.801, the SMC definitions shall be used.**

Aquatic — In or of water. The term can be either a noun or an adjective; the implication is that of fresh water. The term marine (ocean) is typically substituted where reference to salt water is intended.

Bacteria — Bacteria are a major group of micro-organisms that live in soil, water, plants, organic matter, or the bodies of animals or people. They are microscopic and mostly unicellular, with a relatively simple cell structure. Stormwater can contain disease-causing bacteria and viruses.

Baffle — A device to check, deflect, or regulate flow.

Basic treatment facility — A drainage control facility designed to reduce concentrations of total suspended solids in drainage water.

Best management practice (BMP) — A schedule of activities, prohibitions of practices, operational and maintenance procedures, structural facilities, or managerial practice or device that, when used singly or in combination, prevents, reduces, or treats contamination of drainage water, prevents or reduces soil erosion, or prevents or reduces other adverse effects of drainage water on receiving waters. When the Directors develop rules and/or manuals prescribing best management practices for particular purposes, whether or not those rules and/or manuals are adopted by ordinance, BMPs prescribed in the rules and/or manuals shall be the BMPs required for compliance with SMC 22.800 – 22.808.

Biochemical oxygen demand (BOD) — A water quality parameter that indicates the amount of free oxygen utilized by aerobic organisms. Also refer to Chemical Oxygen Demand (COD).

Biodegradable — Capable of being readily broken down by biological means, especially by microbial action. Degradation can be rapid or may take many years depending upon such factors as the nature of the substance and available oxygen and moisture.

Biofilter — Biofilter means a designed treatment facility using a combined soil and vegetation system for filtration, infiltration, adsorption, and biological uptake of pollutants in stormwater when runoff flows over and through. Vegetation growing in these facilities acts as both a physical filter which causes gravity settling of particulates by regulating velocity of flow, and also as a biological sink when direct uptake of dissolved pollutants occurs.

Biofiltration	Biofiltration means the process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.
Capacity-constrained system	A drainage system that the Director of SPU has determined to have inadequate capacity to carry drainage water.
Cause or contribute to a violation	Acts or omissions that create a violation, that increase the duration, extent or severity of a violation, or that aid or abet a violation.
Certified Erosion and Sediment Control Lead (CESCL)	An individual who has current certification through an approved erosion and sediment control training program that meets the minimum training standards established by the Washington State Department of Ecology.
Chemical oxygen demand (COD)	A water quality parameter that represents organic, nitrogenous and other materials that are consumed by bacteria present in receiving waters. Oxygen may be depleted in the process, threatening higher organisms such as fish. The COD test is used to determine the degree of pollution in water. Also refer to Biochemical Oxygen Demand (BOD).
Civil engineer, licensed	A person who is licensed by the State of Washington to practice civil engineering.
Clearing	Clearing means the removal of vegetation, and removal of roots or stumps that include ground disturbance.
Containment area	The area designated for conducting pollution-generating activities for the purposes of implementing source controls or designing and installing source controls or treatment facilities.
Compaction	The densification of earth material by mechanical means.
Construction Stormwater Control Plan	A document that explains and illustrates the measures to be taken on the construction site to control pollutants on a construction project.
Contaminate	The addition of sediment, any other pollutant or waste, or any illicit or prohibited discharge.
Creek	A Type 2-5 water as defined in WAC 222-16-031 and is used synonymously with “stream.”
Designated receiving water	Designated receiving waters include the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, the Lake Washington Ship Canal, and other receiving waters determined by the Director of SPU and approved by Ecology as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control.
Detention	Temporary storage of drainage water for the purpose of controlling the drainage discharge rate.

Development	Land disturbing activity or the addition or replacement of impervious surface.
Director	The Director of the Department authorized to take a particular action, and the Director's designees, who may be employees of that department or another City department.
Discharge point	The location from which drainage water from a site is released.
Drainage basin	The tributary area or subunit of a watershed through which drainage water is collected, regulated, transported, and discharged to receiving waters.
Drainage control	The management of drainage water. Drainage control is accomplished through one or more of the following: collecting, conveying, and discharging drainage water; controlling the discharge rate from a site; controlling the flow duration from a site; and separating, treating or preventing the introduction of pollutants.
Drainage control facility	Any facility, including best management practices, installed or constructed for the purpose of controlling the discharge rate, flow duration, quantity, and/or quality of drainage water.
Drainage control plan	A plan for collecting, controlling, transporting and disposing of drainage water falling upon, entering, flowing within, and exiting the site, including designs for drainage control facilities.
Drainage system	A system intended to collect, convey and control release of only drainage water. The system may be either publicly or privately owned or operated, and the system may serve public or private property. It includes constructed and/or natural components such as pipes, ditches, culverts, streams, creeks, or drainage control facilities.
Drainage water	Stormwater and all other discharges that are permissible per subsection 22.802.030 A.
Enhanced treatment facility	A drainage control facility designed to reduce concentrations of dissolved metals in drainage water.
Erosion	The wearing away of the ground surface as a result of mass wasting or of the movement of wind, water, ice, or other geological agents, including such processes as gravitational creep. Erosion also means the detachment and movement of soil or rock fragments by water, wind, ice, or gravity.
Excavation	The mechanical removal of earth material.
Existing grade	Existing grade means the current surface contour of a site, including minor adjustments to the surface of the site in preparation for construction, or the surface contour that existed immediately prior to grading done without a permit.
Fill	Fill means a deposit of earth material placed by artificial means.

Flow control	Controlling the discharge rate, flow duration, or both of drainage water from the site through means such as infiltration or detention.
Flow control facility	A drainage control facility for controlling the discharge rate, flow duration, or both of drainage water from a site.
Flow-critical receiving water	A surface water that is not a "designated receiving water" as defined in SMC 22.800 – 22.808.
Flow duration	The aggregate time that peak flows are at or above a particular flow rate of interest.
Geotechnical engineer	A professional civil engineer licensed by the State of Washington who has at least four (4) years of professional experience as a geotechnical engineer, including experience with landslide evaluation.
Grading	Excavation, filling, in-place ground modification, removal of roots or stumps that includes ground disturbance, stockpiling of earth materials, or any combination thereof, including the establishment of a grade following demolition of a structure.
Green stormwater infrastructure	A drainage control facility that uses infiltration, evapotranspiration, or stormwater reuse. Examples of green stormwater infrastructure include permeable pavement, bioretention facilities, and green roofs.
Groundwater	Water in a saturated zone or stratum beneath the land surface or a surface waterbody.
Impervious Surface	Any surface exposed to rainwater from which most water runs off. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, formal planters, parking lots or storage areas, concrete or asphalt paving, permeable paving, gravel surfaces subjected to vehicular traffic, compact gravel, packed earthen materials, and oiled macadam or other surfaces which similarly impede the natural infiltration of stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of stormwater modeling.
Industrial activities	Activities such as material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.

Infiltration	The downward movement of water from the surface to the subsoil.
Infiltration facility	A drainage control facility that temporarily stores, and then percolates drainage water into the underlying soil.
Inspector	A City inspector, their designee, or licensed civil engineer performing the inspection work required by SMC 22.800 – 22.808.
Land disturbing activity	Any activity that results in a movement of earth, or a change in the existing soil cover, both vegetative and nonvegetative, or the existing topography. Land disturbing activities include, but are not limited to, clearing, grading, filling, excavation, or addition of new or the replacement of impervious surface. Compaction, excluding hot asphalt mix, which is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land disturbing activities.
Listed creek basins	Listed creek basins include Blue Ridge Creek, Broadview Creek, Discovery Park Creek, Durham Creek, Frink Creek, Golden Gardens Creek, Kiwanis Ravine/Wolfe Creek, Licton Springs Creek, Madrona Park Creek, Mee-Kwa-Mooks Creek, Mount Baker Park Creek, Puget Creek, Riverview Creek, Schmitz Creek, Taylor Creek, or Washington Park Creek.
Maximum extent feasible	Maximum extent feasible means that the requirement is to be fully implemented, constrained only by the physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts.
Metals	Metallic elements that can be beneficial or hazardous to the environment, depending on the type and concentration. Typical metals include copper, zinc, mercury, chromium, cadmium, arsenic, and lead.
Monitoring	The collection of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures imposed as conditions of development.
Municipal stormwater NPDES permit	The permit issued to the City under the federal Clean Water Act for public drainage systems within the City limits.
NPDES	National Pollutant Discharge Elimination System, the national program for controlling discharges under the federal Clean Water Act.
NPDES permit	An authorization, license or equivalent control document issued by the United States Environmental Protection Agency or the Washington State Department of Ecology to implement the requirements of the NPDES program.

Nutrients	Essential chemicals, such as phosphorus and nitrogen, needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and algal blooms. Some nutrients can be toxic at high concentrations.
Oil control treatment facility	A drainage control facility designed to reduce concentrations of oil in drainage water.
Outlet Trap	A tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze.
Pervious surface	A surface that is not impervious. See also “impervious surface.”
Petroleum Hydrocarbons	This is a term used to refer to a broad range of petroleum products such as mineral oil, gasoline, diesel, heating oil, lubricant oil, and hydraulic fluid.
pH	The "pH" value is a measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acidic.
Plan	A graphic or schematic representation, with accompanying notes, schedules, specifications and other related documents, or a document consisting of checklists, steps, actions, schedules, or other contents that has been prepared pursuant to SMC 22.800 – 22.808, such as a drainage control plan, construction stormwater control plan, stormwater pollution prevention plan, and integrated drainage plan.
Pollution-generating activity	Any activity that is regulated by the joint SPU/DPD Directors’ Rule titled “Source Control Technical Requirements Manual” or activities with similar impacts on drainage water. These activities include, but are not limited to: cleaning and washing activities; transfer of liquid or solid material; production and application activities; dust, soil, and sediment control; commercial animal care and handling; log sorting and handling; boat building, mooring, maintenance, and repair; logging and tree removal; mining and quarrying of sand, gravel, rock, peat, clay, and other materials; cleaning and maintenance of swimming pool and spas; deicing and anti-icing operations for airports and streets; maintenance and management of roof and building drains at manufacturing and commercial buildings; maintenance and operation of railroad yards; maintenance of public and utility corridors and facilities; and maintenance of roadside ditches.

Pollution-generating impervious surface

Those impervious surfaces considered to be a significant source of pollutants in drainage water. Such surfaces include those that are subject to: vehicular use; certain industrial activities; or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Erodible or leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the drainage water. Examples include: erodible soils that are stockpiled; uncovered process wastes; manure; fertilizers; oily substances; ashes; kiln dust; and garbage dumpster leakage. Metal roofs are also considered to be PGIS unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating).

A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads; unvegetated road shoulders; permeable pavement; bike lanes within the traveled lane of a roadway; driveways; parking lots; unfenced fire lanes; vehicular equipment storage yards; and airport runways.

The following are not considered regularly-used surfaces: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles; fenced fire lanes; and infrequently used maintenance access roads.

Pollution-generating pervious surface

Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil, and typically includes lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Pre-developed condition

The vegetation and soil conditions that are used to determine the allowable post-development discharge peak flow rates and flow durations, such as pasture or forest.

Project

The addition or replacement of impervious surface or the undertaking of land disturbing activity on a site.

Public combined sewer

A publicly owned and maintained system which carries drainage water and wastewater and flows to a publicly owned treatment works.

Public drainage system

A drainage system owned or used by the City of Seattle.

Public sanitary sewer

The sanitary sewer that is owned or operated by a City agency.

Public storm drain

The part of a public drainage system that is wholly or partially piped, owned or operated by a City agency, and designed to carry only drainage water.

Receiving water

The surface water or wetland receiving drainage water.

Recommended BMPs Recommended BMPs are those source control BMPs that are not mandatory for activities or at new development and redevelopment sites. However, they may improve pollutant control efficiency, and may provide a more comprehensive and environmentally effective stormwater management program.

Replaced impervious surface For structures, the removal and replacement of impervious surface down to the foundation. For other impervious surface, the impervious surface that is removed down to earth material and a new impervious surface is installed.

Required BMPs Required BMPs are those BMPs that are required by the City of Seattle for applicable activities, in accordance with the City of Seattle Stormwater Code.

Secondary containment Secondary containment provides a barrier between a container (e.g., fuel tank, drum, paint cans) and the environment. The barrier holds the leaked material until the leak is detected and fixed. The barrier also prevents stormwater from being polluted in the event of a spill or leak. Examples include an impervious dike, berm, or retaining wall; a temporary pan, tub, or absorptive pad can be used to contain incidental leaks.

Single-family residential project A project, that constructs one Single-family Dwelling Unit per SMC 23.44.006.A located in land classified as being Single-family Residential 9,600 (SF 9600), Single-family Residential 7,200 (SF 7200), or Single-family Residential 5,000 (SF 5000) per SMC 23.30.010, and the total new plus replaced impervious surface is less than 10,000 square feet and the total new plus replaced pollution-generating impervious surface is less than 5,000 square feet.

Site The lot or parcel, or portion of street, highway or other right-of-way, or contiguous combination thereof, where a permit for the addition or replacement of impervious surface or the undertaking of land disturbing activity has been issued or where any such work is proposed or performed. For roadway projects, the length of the project site and the right-of-way boundaries define the site.

Sludge A generic term for solids separated from suspension in a liquid by a variety of processes.

Source controls Structures or operations that prevent contaminants from coming in contact with drainage water through physical separation or careful management of activities that are known sources of pollution.

Stormwater That portion of precipitation and snowmelt that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a drainage system into a receiving water or a constructed infiltration facility.

Sump	A sump, commonly found in the home basement, is simply a hole to collect water that has entered because of rain or because of natural groundwater. Some businesses use sumps to collect liquids from their operations (e.g., oil change operation). A sump pump is commonly used to move the liquid to a disposal point or the liquid is pumped out and disposed separately.
Total suspended solids (TSS)	That portion of the solids carried by stormwater that can be captured on a standard glass filter.
Treatment Facility	A drainage control facility designed to remove pollutants from drainage water.
Turbidity	A measure of water clarity. Color or cloudiness in a liquid caused by the dispersion or scattering of light, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.
Water quality	A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Quality Standards	Surface Water Quality Standards, Chapter 173-201A WAC, Ground Water Quality Standards, Chapter 173-200 WAC, and Sediment Management Standards, Chapter 173-204 WAC.
Watershed	A geographic region within which water drains into a particular river, stream, or other body of water.
Wetland function	The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. Wetland functions can be grouped into three categories: functions that improve water quality; functions that change the water regime in a watershed, such as flood storage; and functions that provide habitat for plants and animals.

Appendix B –

Design Storm Dimensionless Hyetograph Ordinates

Appendix B - Design Storm Dimensionless Hyetograph Ordinates

Table B-1. Dimensionless Ordinates of the Short-Duration Design Storm.

DIMENSIONLESS ORDINATES OF SHORT-DURATION DESIGN STORM		
ELAPSED TIME (Min)	**INCREMENTAL ORDINATES**	**CUMULATIVE ORDINATES**
0	0.0000	0.0000
5	0.0045	0.0045
10	0.0055	0.0100
15	0.0075	0.0175
20	0.0086	0.0261
25	0.0102	0.0363
30	0.0134	0.0497
35	0.0173	0.0670
40	0.0219	0.0889
45	0.0272	0.1161
50	0.0331	0.1492
55	0.0364	0.1856
60	0.0434	0.2290
65	0.0553	0.2843
70	0.0659	0.3502
75	0.1200	0.4702
80	0.1900	0.6602
85	0.1000	0.7602
90	0.0512	0.8114
95	0.0472	0.8586
100	0.0398	0.8984
105	0.0301	0.9285
110	0.0244	0.9529
115	0.0195	0.9724
120	0.0153	0.9877
125	0.0125	1.0002
130	0.0096	1.0098
135	0.0077	1.0175
140	0.0068	1.0243
145	0.0062	1.0305
150	0.0056	1.0361
155	0.0050	1.0411
160	0.0044	1.0455
165	0.0038	1.0493
170	0.0032	1.0525
175	0.0026	1.0551
180	0.0020	1.0571

Table B-2. Dimensionless Ordinates of the Intermediate-Duration Design Storm.

DIMENSIONLESS ORDINATES OF INTERMEDIATE-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
0.00	0.0000	0.0000	6.17	0.0118	0.1972	12.17	0.0210	1.1731
0.17	0.0020	0.0020	6.33	0.0123	0.2095	12.33	0.0201	1.1932
0.33	0.0020	0.0040	6.50	0.0129	0.2224	12.50	0.0193	1.2125
0.50	0.0020	0.0060	6.67	0.0136	0.2360	12.67	0.0184	1.2309
0.67	0.0020	0.0080	6.83	0.0142	0.2502	12.83	0.0176	1.2485
0.83	0.0020	0.0100	7.00	0.0150	0.2652	13.00	0.0168	1.2653
1.00	0.0021	0.0121	7.17	0.0163	0.2815	13.17	0.0154	1.2807
1.17	0.0021	0.0142	7.33	0.0171	0.2986	13.33	0.0147	1.2954
1.33	0.0021	0.0163	7.50	0.0180	0.3166	13.50	0.0140	1.3094
1.50	0.0021	0.0184	7.67	0.0188	0.3354	13.67	0.0132	1.3226
1.67	0.0021	0.0205	7.83	0.0197	0.3551	13.83	0.0127	1.3353
1.83	0.0022	0.0227	8.00	0.0205	0.3756	14.00	0.0121	1.3474
2.00	0.0022	0.0249	8.17	0.0215	0.3971	14.17	0.0116	1.3590
2.17	0.0023	0.0272	8.33	0.0224	0.4195	14.33	0.0113	1.3703
2.33	0.0023	0.0295	8.50	0.0229	0.4424	14.50	0.0111	1.3814
2.50	0.0024	0.0319	8.67	0.0232	0.4656	14.67	0.0109	1.3923
2.67	0.0025	0.0344	8.83	0.0237	0.4893	14.83	0.0107	1.4030
2.83	0.0028	0.0372	9.00	0.0257	0.5150	15.00	0.0105	1.4135
3.00	0.0030	0.0402	9.17	0.0290	0.5440	15.17	0.0103	1.4238
3.17	0.0034	0.0436	9.33	0.0320	0.5760	15.33	0.0098	1.4336
3.33	0.0038	0.0474	9.50	0.0338	0.6098	15.50	0.0093	1.4429
3.50	0.0042	0.0516	9.67	0.0349	0.6447	15.67	0.0085	1.4514
3.67	0.0046	0.0562	9.83	0.0411	0.6858	15.83	0.0078	1.4592
3.83	0.0054	0.0616	10.00	0.0540	0.7398	16.00	0.0070	1.4662
4.00	0.0062	0.0678	10.17	0.0760	0.8158	16.17	0.0062	1.4724
4.17	0.0070	0.0748	10.33	0.0470	0.8628	16.33	0.0054	1.4778
4.33	0.0079	0.0827	10.50	0.0372	0.9000	16.50	0.0049	1.4827
4.50	0.0085	0.0912	10.67	0.0347	0.9347	16.67	0.0044	1.4871
4.67	0.0090	0.1002	10.83	0.0337	0.9684	16.83	0.0039	1.4910
4.83	0.0095	0.1097	11.00	0.0330	1.0014	17.00	0.0035	1.4945
5.00	0.0100	0.1197	11.17	0.0308	1.0322	17.17	0.0032	1.4977
5.17	0.0104	0.1301	11.33	0.0269	1.0591	17.33	0.0029	1.5006
5.33	0.0107	0.1408	11.50	0.0247	1.0838	17.50	0.0026	1.5032
5.50	0.0109	0.1517	11.67	0.0237	1.1075	17.67	0.0024	1.5056
5.67	0.0110	0.1627	11.83	0.0228	1.1303	17.83	0.0024	1.5080
5.83	0.0113	0.1740	12.00	0.0218	1.1521	18.00	0.0023	1.5103
6.00	0.0114	0.1854						

Table B-3. Dimensionless Ordinates of Front-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF INTERMEDIATE-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
0.00	0.0000	0.0000	7.17	0.0018	0.0569	14.17	0.0072	0.2570
0.17	0.0001	0.0001	7.33	0.0019	0.0588	14.33	0.0073	0.2643
0.33	0.0003	0.0004	7.50	0.0019	0.0607	14.50	0.0074	0.2717
0.50	0.0005	0.0009	7.67	0.0020	0.0627	14.67	0.0075	0.2792
0.67	0.0007	0.0016	7.83	0.0022	0.0649	14.83	0.0076	0.2868
0.83	0.0009	0.0025	8.00	0.0024	0.0673	15.00	0.0077	0.2945
1.00	0.0010	0.0035	8.17	0.0026	0.0699	15.17	0.0078	0.3023
1.17	0.0011	0.0046	8.33	0.0028	0.0727	15.33	0.0078	0.3101
1.33	0.0012	0.0058	8.50	0.0030	0.0757	15.50	0.0078	0.3179
1.50	0.0013	0.0071	8.67	0.0032	0.0789	15.67	0.0079	0.3258
1.67	0.0013	0.0084	8.83	0.0034	0.0823	15.83	0.0079	0.3337
1.83	0.0013	0.0097	9.00	0.0036	0.0859	16.00	0.0079	0.3416
2.00	0.0013	0.0110	9.17	0.0038	0.0897	16.17	0.0081	0.3497
2.17	0.0013	0.0123	9.33	0.0040	0.0937	16.33	0.0082	0.3579
2.33	0.0013	0.0136	9.50	0.0042	0.0979	16.50	0.0082	0.3661
2.50	0.0014	0.0150	9.67	0.0045	0.1024	16.67	0.0093	0.3754
2.67	0.0014	0.0164	9.83	0.0047	0.1071	16.83	0.0099	0.3853
2.83	0.0014	0.0178	10.00	0.0048	0.1119	17.00	0.0102	0.3955
3.00	0.0014	0.0192	10.17	0.0049	0.1168	17.17	0.0104	0.4059
3.17	0.0014	0.0206	10.33	0.0049	0.1217	17.33	0.0107	0.4166
3.33	0.0014	0.0220	10.50	0.0049	0.1266	17.50	0.0114	0.4280
3.50	0.0014	0.0234	10.67	0.0050	0.1316	17.67	0.0118	0.4398
3.67	0.0014	0.0248	10.83	0.0051	0.1367	17.83	0.0142	0.4540
3.83	0.0014	0.0262	11.00	0.0051	0.1418	18.00	0.0220	0.4760
4.00	0.0014	0.0276	11.17	0.0053	0.1471	18.17	0.0290	0.5050
4.17	0.0014	0.0290	11.33	0.0053	0.1524	18.33	0.0160	0.5210
4.33	0.0015	0.0305	11.50	0.0054	0.1578	18.50	0.0127	0.5337
4.50	0.0015	0.0320	11.67	0.0054	0.1632	18.67	0.0116	0.5453
4.67	0.0015	0.0335	11.83	0.0054	0.1686	18.83	0.0110	0.5563
4.83	0.0015	0.0350	12.00	0.0055	0.1741	19.00	0.0106	0.5669
5.00	0.0015	0.0365	12.17	0.0055	0.1796	19.17	0.0102	0.5771
5.17	0.0015	0.0380	12.33	0.0056	0.1852	19.33	0.0096	0.5867
5.33	0.0015	0.0395	12.50	0.0057	0.1909	19.50	0.0082	0.5949
5.50	0.0015	0.0410	12.67	0.0058	0.1967	19.67	0.0082	0.6031
5.67	0.0015	0.0425	12.83	0.0060	0.2027	19.83	0.0082	0.6113
5.83	0.0015	0.0440	13.00	0.0062	0.2089	20.00	0.0081	0.6194
6.00	0.0015	0.0455	13.17	0.0064	0.2153	20.17	0.0080	0.6274
6.17	0.0015	0.0470	13.33	0.0066	0.2219	20.33	0.0079	0.6353
6.33	0.0015	0.0485	13.50	0.0068	0.2287	20.50	0.0079	0.6432

Table B-3 (continued). Dimensionless Ordinates of Front-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF INTERMEDIATE-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
6.50	0.0016	0.0501	13.67	0.0069	0.2356	20.67	0.0078	0.6510
6.67	0.0016	0.0517	13.83	0.0070	0.2426	20.83	0.0078	0.6588
6.83	0.0017	0.0534	14.00	0.0072	0.2498	21.00	0.0077	0.6665
7.00	0.0017	0.0551						
21.17	0.0077	0.6742	30.17	0.0050	1.0069	39.17	0.0000	1.0984
21.33	0.0077	0.6819	30.33	0.0049	1.0118	39.33	0.0000	1.0984
21.50	0.0077	0.6896	30.50	0.0049	1.0167	39.50	0.0000	1.0984
21.67	0.0076	0.6972	30.67	0.0049	1.0216	39.67	0.0000	1.0984
21.83	0.0075	0.7047	30.83	0.0049	1.0265	39.83	0.0000	1.0984
22.00	0.0075	0.7122	31.00	0.0048	1.0313	40.00	0.0000	1.0984
22.17	0.0074	0.7196	31.17	0.0048	1.0361	40.17	0.0000	1.0984
22.33	0.0074	0.7270	31.33	0.0048	1.0409	40.33	0.0000	1.0984
22.50	0.0073	0.7343	31.50	0.0047	1.0456	40.50	0.0000	1.0984
22.67	0.0073	0.7416	31.67	0.0046	1.0502	40.67	0.0000	1.0984
22.83	0.0073	0.7489	31.83	0.0045	1.0547	40.83	0.0000	1.0984
23.00	0.0072	0.7561	32.00	0.0044	1.0591	41.00	0.0000	1.0984
23.17	0.0072	0.7633	32.17	0.0043	1.0634	41.17	0.0000	1.0984
23.33	0.0072	0.7705	32.33	0.0042	1.0676	41.33	0.0000	1.0984
23.50	0.0071	0.7776	32.50	0.0041	1.0717	41.50	0.0000	1.0984
23.67	0.0071	0.7847	32.67	0.0039	1.0756	41.67	0.0000	1.0984
23.83	0.0070	0.7917	32.83	0.0038	1.0794	41.83	0.0000	1.0984
24.00	0.0070	0.7987	33.00	0.0037	1.0831	42.00	0.0000	1.0984
24.17	0.0069	0.8056	33.17	0.0033	1.0864	42.17	0.0000	1.0984
24.33	0.0068	0.8124	33.33	0.0029	1.0893	42.33	0.0000	1.0984
24.50	0.0067	0.8191	33.50	0.0025	1.0918	42.50	0.0000	1.0984
24.67	0.0067	0.8258	33.67	0.0021	1.0939	42.67	0.0000	1.0984
24.83	0.0066	0.8324	33.83	0.0017	1.0956	42.83	0.0000	1.0984
25.00	0.0065	0.8389	34.00	0.0013	1.0969	43.00	0.0000	1.0984
25.17	0.0062	0.8451	34.17	0.0009	1.0978	43.17	0.0000	1.0984
25.33	0.0062	0.8513	34.33	0.0005	1.0983	43.33	0.0000	1.0984
25.50	0.0060	0.8573	34.50	0.0001	1.0984	43.50	0.0000	1.0984
25.67	0.0059	0.8632	34.67	0.0000	1.0984	43.67	0.0000	1.0984
25.83	0.0059	0.8691	34.83	0.0000	1.0984	43.83	0.0000	1.0984
26.00	0.0058	0.8749	35.00	0.0000	1.0984	44.00	0.0000	1.0984
26.17	0.0057	0.8806	35.17	0.0000	1.0984	44.17	0.0000	1.0984
26.33	0.0056	0.8862	35.33	0.0000	1.0984	44.33	0.0000	1.0984
26.50	0.0055	0.8917	35.50	0.0000	1.0984	44.50	0.0000	1.0984
26.67	0.0055	0.8972	35.67	0.0000	1.0984	44.67	0.0000	1.0984

Table B-3 (continued). Dimensionless Ordinates of Front-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF INTERMEDIATE-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
26.83	0.0055	0.9027	35.83	0.0000	1.0984	44.83	0.0000	1.0984
27.00	0.0055	0.9082	36.00	0.0000	1.0984	45.00	0.0000	1.0984
27.17	0.0054	0.9136	36.17	0.0000	1.0984	45.17	0.0000	1.0984
27.33	0.0054	0.9190	36.33	0.0000	1.0984	45.33	0.0000	1.0984
27.50	0.0054	0.9244	36.50	0.0000	1.0984	45.50	0.0000	1.0984
27.67	0.0053	0.9297	36.67	0.0000	1.0984	45.67	0.0000	1.0984
27.83	0.0053	0.9350	36.83	0.0000	1.0984	45.83	0.0000	1.0984
28.00	0.0053	0.9403	37.00	0.0000	1.0984	46.00	0.0000	1.0984
28.17	0.0053	0.9456	37.17	0.0000	1.0984	46.17	0.0000	1.0984
28.33	0.0052	0.9508	37.33	0.0000	1.0984	46.33	0.0000	1.0984
28.50	0.0052	0.9560	37.50	0.0000	1.0984	46.50	0.0000	1.0984
28.67	0.0052	0.9612	37.67	0.0000	1.0984	46.67	0.0000	1.0984
28.83	0.0052	0.9664	37.83	0.0000	1.0984	46.83	0.0000	1.0984
29.00	0.0052	0.9716	38.00	0.0000	1.0984	47.00	0.0000	1.0984
29.17	0.0051	0.9767	38.17	0.0000	1.0984	47.17	0.0000	1.0984
29.33	0.0051	0.9818	38.33	0.0000	1.0984	47.33	0.0000	1.0984
29.50	0.0051	0.9869	38.50	0.0000	1.0984	47.50	0.0000	1.0984
29.67	0.0050	0.9919	38.67	0.0000	1.0984	47.67	0.0001	1.0985
29.83	0.0050	0.9969	38.83	0.0000	1.0984	47.83	0.0002	1.0987
30.00	0.0050	1.0019	39.00	0.0000	1.0984	48.00	0.0003	1.0990
48.17	0.0004	1.0994	56.17	0.0026	1.2422			
48.33	0.0005	1.0999	56.33	0.0024	1.2446			
48.50	0.0006	1.1005	56.50	0.0023	1.2469			
48.67	0.0007	1.1012	56.67	0.0023	1.2492			
48.83	0.0007	1.1019	56.83	0.0022	1.2514			
49.00	0.0007	1.1026	57.00	0.0021	1.2535			
49.17	0.0007	1.1033	57.17	0.0019	1.2554			
49.33	0.0007	1.1040	57.33	0.0017	1.2571			
49.50	0.0007	1.1047	57.50	0.0016	1.2587			
49.67	0.0007	1.1054	57.67	0.0015	1.2602			
49.83	0.0007	1.1061	57.83	0.0015	1.2617			
50.00	0.0007	1.1068	58.00	0.0015	1.2632			
50.17	0.0007	1.1075	58.17	0.0015	1.2647			
50.33	0.0008	1.1083	58.33	0.0015	1.2662			
50.50	0.0009	1.1092	58.50	0.0015	1.2677			
50.67	0.0010	1.1102	58.67	0.0014	1.2691			
50.83	0.0011	1.1113	58.83	0.0014	1.2705			
51.00	0.0012	1.1125	59.00	0.0013	1.2718			

Table B-3 (continued). Dimensionless Ordinates of Front-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF INTERMEDIATE-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
51.17	0.0013	1.1138	59.17	0.0013	1.2731			
51.33	0.0014	1.1152	59.33	0.0012	1.2743			
51.50	0.0014	1.1166	59.50	0.0012	1.2755			
51.67	0.0014	1.1180	59.67	0.0011	1.2766			
51.83	0.0014	1.1194	59.83	0.0010	1.2776			
52.00	0.0015	1.1209	60.00	0.0009	1.2785			
52.17	0.0016	1.1225	60.17	0.0009	1.2794			
52.33	0.0018	1.1243	60.33	0.0008	1.2802			
52.50	0.0020	1.1263	60.50	0.0008	1.2810			
52.67	0.0021	1.1284	60.67	0.0007	1.2817			
52.83	0.0023	1.1307	60.83	0.0007	1.2824			
53.00	0.0023	1.1330	61.00	0.0007	1.2831			
53.17	0.0024	1.1354	61.17	0.0007	1.2838			
53.33	0.0026	1.1380	61.33	0.0007	1.2845			
53.50	0.0028	1.1408	61.50	0.0007	1.2852			
53.67	0.0032	1.1440	61.67	0.0007	1.2859			
53.83	0.0039	1.1479	61.83	0.0007	1.2866			
54.00	0.0048	1.1527	62.00	0.0007	1.2873			
54.17	0.0056	1.1583	62.17	0.0007	1.2880			
54.33	0.0076	1.1659	62.33	0.0007	1.2887			
54.50	0.0096	1.1755	62.50	0.0007	1.2894			
54.67	0.0133	1.1888	62.67	0.0006	1.2900			
54.83	0.0133	1.2021	62.83	0.0005	1.2905			
55.00	0.0096	1.2117	63.00	0.0004	1.2909			
55.17	0.0076	1.2193	63.17	0.0003	1.2912			
55.33	0.0056	1.2249	63.33	0.0002	1.2914			
55.50	0.0048	1.2297	63.50	0.0001	1.2915			
55.67	0.0039	1.2336	63.67	0.0000	1.2915			
55.83	0.0032	1.2368	63.83	0.0000	1.2915			
56.00	0.0028	1.2396	64.00	0.0000	1.2915			

Table B-4. Dimensionless Ordinates of Back-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF BACK-LOADED LONG-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
0.00	0.0000	0.0000	8.17	0.0039	0.1352	16.17	0.0000	0.1931
0.17	0.0001	0.0001	8.33	0.0032	0.1384	16.33	0.0000	0.1931
0.33	0.0002	0.0003	8.50	0.0028	0.1412	16.50	0.0000	0.1931
0.50	0.0003	0.0006	8.67	0.0026	0.1438	16.67	0.0000	0.1931
0.67	0.0004	0.0010	8.83	0.0024	0.1462	16.83	0.0000	0.1931
0.83	0.0005	0.0015	9.00	0.0023	0.1485	17.00	0.0000	0.1931
1.00	0.0006	0.0021	9.17	0.0023	0.1508	17.17	0.0000	0.1931
1.17	0.0007	0.0028	9.33	0.0022	0.1530	17.33	0.0000	0.1931
1.33	0.0007	0.0035	9.50	0.0021	0.1551	17.50	0.0000	0.1931
1.50	0.0007	0.0042	9.67	0.0019	0.1570	17.67	0.0000	0.1931
1.67	0.0007	0.0049	9.83	0.0017	0.1587	17.83	0.0000	0.1931
1.83	0.0007	0.0056	10.00	0.0016	0.1603	18.00	0.0000	0.1931
2.00	0.0007	0.0063	10.17	0.0015	0.1618	18.17	0.0000	0.1931
2.17	0.0007	0.0070	10.33	0.0015	0.1633	18.33	0.0000	0.1931
2.33	0.0007	0.0077	10.50	0.0015	0.1648	18.50	0.0000	0.1931
2.50	0.0007	0.0084	10.67	0.0015	0.1663	18.67	0.0000	0.1931
2.67	0.0007	0.0091	10.83	0.0015	0.1678	18.83	0.0000	0.1931
2.83	0.0008	0.0099	11.00	0.0015	0.1693	19.00	0.0000	0.1931
3.00	0.0009	0.0108	11.17	0.0014	0.1707	19.17	0.0000	0.1931
3.17	0.0010	0.0118	11.33	0.0014	0.1721	19.33	0.0000	0.1931
3.33	0.0011	0.0129	11.50	0.0013	0.1734	19.50	0.0000	0.1931
3.50	0.0012	0.0141	11.67	0.0013	0.1747	19.67	0.0000	0.1931
3.67	0.0013	0.0154	11.83	0.0012	0.1759	19.83	0.0000	0.1931
3.83	0.0014	0.0168	12.00	0.0012	0.1771	20.00	0.0000	0.1931
4.00	0.0014	0.0182	12.17	0.0011	0.1782	20.17	0.0000	0.1931
4.17	0.0014	0.0196	12.33	0.0010	0.1792	20.33	0.0000	0.1931
4.33	0.0014	0.0210	12.50	0.0009	0.1801	20.50	0.0000	0.1931
4.50	0.0015	0.0225	12.67	0.0009	0.1810	20.67	0.0000	0.1931
4.67	0.0016	0.0241	12.83	0.0008	0.1818	20.83	0.0000	0.1931
4.83	0.0018	0.0259	13.00	0.0008	0.1826	21.00	0.0000	0.1931
5.00	0.0020	0.0279	13.17	0.0007	0.1833	21.17	0.0000	0.1931
5.17	0.0021	0.0300	13.33	0.0007	0.1840	21.33	0.0000	0.1931
5.33	0.0023	0.0323	13.50	0.0007	0.1847	21.50	0.0000	0.1931
5.50	0.0023	0.0346	13.67	0.0007	0.1854	21.67	0.0000	0.1931
5.67	0.0024	0.0370	13.83	0.0007	0.1861	21.83	0.0000	0.1931
5.83	0.0026	0.0396	14.00	0.0007	0.1868	22.00	0.0000	0.1931
6.00	0.0028	0.0424	14.17	0.0007	0.1875	22.17	0.0000	0.1931
6.17	0.0032	0.0456	14.33	0.0007	0.1882	22.33	0.0000	0.1931
6.33	0.0039	0.0495	14.50	0.0007	0.1889	22.50	0.0000	0.1931
6.50	0.0048	0.0543	14.67	0.0007	0.1896	22.67	0.0000	0.1931

Table B-4 (continued). Dimensionless Ordinates of Back-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF BACK-LOADED LONG-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
6.67	0.0056	0.0599	14.83	0.0007	0.1903	22.83	0.0000	0.1931
6.83	0.0076	0.0675	15.00	0.0007	0.1910	23.00	0.0000	0.1931
7.00	0.0096	0.0771	15.17	0.0006	0.1916	23.17	0.0000	0.1931
7.17	0.0133	0.0904	15.33	0.0005	0.1921	23.33	0.0000	0.1931
7.33	0.0133	0.1037	15.50	0.0004	0.1925	23.50	0.0000	0.1931
7.50	0.0096	0.1133	15.67	0.0003	0.1928	23.67	0.0000	0.1931
7.67	0.0076	0.1209	15.83	0.0002	0.1930	23.83	0.0000	0.1931
7.83	0.0056	0.1265	16.00	0.0001	0.1931	24.00	0.0000	0.1931
8.00	0.0048	0.1313						
24.17	0.0000	0.1931	32.17	0.0014	0.2137	40.17	0.0053	0.3402
24.33	0.0000	0.1931	32.33	0.0014	0.2151	40.33	0.0053	0.3455
24.50	0.0000	0.1931	32.50	0.0014	0.2165	40.50	0.0054	0.3509
24.67	0.0000	0.1931	32.67	0.0014	0.2179	40.67	0.0054	0.3563
24.83	0.0000	0.1931	32.83	0.0014	0.2193	40.83	0.0054	0.3617
25.00	0.0000	0.1931	33.00	0.0014	0.2207	41.00	0.0055	0.3672
25.17	0.0000	0.1931	33.17	0.0014	0.2221	41.17	0.0055	0.3727
25.33	0.0000	0.1931	33.33	0.0015	0.2236	41.33	0.0056	0.3783
25.50	0.0000	0.1931	33.50	0.0015	0.2251	41.50	0.0057	0.3840
25.67	0.0000	0.1931	33.67	0.0015	0.2266	41.67	0.0058	0.3898
25.83	0.0000	0.1931	33.83	0.0015	0.2281	41.83	0.0060	0.3958
26.00	0.0000	0.1931	34.00	0.0015	0.2296	42.00	0.0062	0.4020
26.17	0.0000	0.1931	34.17	0.0015	0.2311	42.17	0.0064	0.4084
26.33	0.0000	0.1931	34.33	0.0015	0.2326	42.33	0.0066	0.4150
26.50	0.0000	0.1931	34.50	0.0015	0.2341	42.50	0.0068	0.4218
26.67	0.0000	0.1931	34.67	0.0015	0.2356	42.67	0.0069	0.4287
26.83	0.0000	0.1931	34.83	0.0015	0.2371	42.83	0.0070	0.4357
27.00	0.0000	0.1931	35.00	0.0015	0.2386	43.00	0.0072	0.4429
27.17	0.0000	0.1931	35.17	0.0015	0.2401	43.17	0.0072	0.4501
27.33	0.0000	0.1931	35.33	0.0015	0.2416	43.33	0.0073	0.4574
27.50	0.0000	0.1931	35.50	0.0016	0.2432	43.50	0.0074	0.4648
27.67	0.0000	0.1931	35.67	0.0016	0.2448	43.67	0.0075	0.4723
27.83	0.0000	0.1931	35.83	0.0017	0.2465	43.83	0.0076	0.4799
28.00	0.0000	0.1931	36.00	0.0017	0.2482	44.00	0.0077	0.4876
28.17	0.0000	0.1931	36.17	0.0018	0.2500	44.17	0.0078	0.4954
28.33	0.0000	0.1931	36.33	0.0019	0.2519	44.33	0.0078	0.5032
28.50	0.0000	0.1931	36.50	0.0019	0.2538	44.50	0.0078	0.5110
28.67	0.0000	0.1931	36.67	0.0020	0.2558	44.67	0.0079	0.5189
28.83	0.0000	0.1931	36.83	0.0022	0.2580	44.83	0.0079	0.5268
29.00	0.0000	0.1931	37.00	0.0024	0.2604	45.00	0.0079	0.5347

Table B-4 (continued). Dimensionless Ordinates of Back-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF BACK-LOADED LONG-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
29.17	0.0001	0.1932	37.17	0.0026	0.2630	45.17	0.0081	0.5428
29.33	0.0003	0.1935	37.33	0.0028	0.2658	45.33	0.0082	0.5510
29.50	0.0005	0.1940	37.50	0.0030	0.2688	45.50	0.0082	0.5592
29.67	0.0007	0.1947	37.67	0.0032	0.2720	45.67	0.0093	0.5685
29.83	0.0009	0.1956	37.83	0.0034	0.2754	45.83	0.0099	0.5784
30.00	0.0010	0.1966	38.00	0.0036	0.2790	46.00	0.0102	0.5886
30.17	0.0011	0.1977	38.17	0.0038	0.2828	46.17	0.0104	0.5990
30.33	0.0012	0.1989	38.33	0.0040	0.2868	46.33	0.0107	0.6097
30.50	0.0013	0.2002	38.50	0.0042	0.2910	46.50	0.0114	0.6211
30.67	0.0013	0.2015	38.67	0.0045	0.2955	46.67	0.0118	0.6329
30.83	0.0013	0.2028	38.83	0.0047	0.3002	46.83	0.0142	0.6471
31.00	0.0013	0.2041	39.00	0.0048	0.3050	47.00	0.0220	0.6691
31.17	0.0013	0.2054	39.17	0.0049	0.3099	47.17	0.0290	0.6981
31.33	0.0013	0.2067	39.33	0.0049	0.3148	47.33	0.0160	0.7141
31.50	0.0014	0.2081	39.50	0.0049	0.3197	47.50	0.0127	0.7268
31.67	0.0014	0.2095	39.67	0.0050	0.3247	47.67	0.0116	0.7384
31.83	0.0014	0.2109	39.83	0.0051	0.3298	47.83	0.0110	0.7494
32.00	0.0014	0.2123	40.00	0.0051	0.3349	48.00	0.0106	0.7600
48.17	0.0102	0.7702	56.17	0.0054	1.1067			
48.33	0.0096	0.7798	56.33	0.0054	1.1121			
48.50	0.0082	0.7880	56.50	0.0054	1.1175			
48.67	0.0082	0.7962	56.67	0.0053	1.1228			
48.83	0.0082	0.8044	56.83	0.0053	1.1281			
49.00	0.0081	0.8125	57.00	0.0053	1.1334			
49.17	0.0080	0.8205	57.17	0.0053	1.1387			
49.33	0.0079	0.8284	57.33	0.0052	1.1439			
49.50	0.0079	0.8363	57.50	0.0052	1.1491			
49.67	0.0078	0.8441	57.67	0.0052	1.1543			
49.83	0.0078	0.8519	57.83	0.0052	1.1595			
50.00	0.0077	0.8596	58.00	0.0052	1.1647			
50.17	0.0077	0.8673	58.17	0.0051	1.1698			
50.33	0.0077	0.8750	58.33	0.0051	1.1749			
50.50	0.0077	0.8827	58.50	0.0051	1.1800			
50.67	0.0076	0.8903	58.67	0.0050	1.1850			
50.83	0.0075	0.8978	58.83	0.0050	1.1900			
51.00	0.0075	0.9053	59.00	0.0050	1.1950			
51.17	0.0074	0.9127	59.17	0.0050	1.2000			
51.33	0.0074	0.9201	59.33	0.0049	1.2049			
51.50	0.0073	0.9274	59.50	0.0049	1.2098			

Table B-4 (continued). Dimensionless Ordinates of Back-Loaded Long-Duration Design Storm.

DIMENSIONLESS ORDINATES OF BACK-LOADED LONG-DURATION DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
51.67	0.0073	0.9347	59.67	0.0049	1.2147			
51.83	0.0073	0.9420	59.83	0.0049	1.2196			
52.00	0.0072	0.9492	60.00	0.0048	1.2244			
52.17	0.0072	0.9564	60.17	0.0048	1.2292			
52.33	0.0072	0.9636	60.33	0.0048	1.2340			
52.50	0.0071	0.9707	60.50	0.0047	1.2387			
52.67	0.0071	0.9778	60.67	0.0046	1.2433			
52.83	0.0070	0.9848	60.83	0.0045	1.2478			
53.00	0.0070	0.9918	61.00	0.0044	1.2522			
53.17	0.0069	0.9987	61.17	0.0043	1.2565			
53.33	0.0068	1.0055	61.33	0.0042	1.2607			
53.50	0.0067	1.0122	61.50	0.0041	1.2648			
53.67	0.0067	1.0189	61.67	0.0039	1.2687			
53.83	0.0066	1.0255	61.83	0.0038	1.2725			
54.00	0.0065	1.0320	62.00	0.0037	1.2762			
54.17	0.0062	1.0382	62.17	0.0033	1.2795			
54.33	0.0062	1.0444	62.33	0.0029	1.2824			
54.50	0.0060	1.0504	62.50	0.0025	1.2849			
54.67	0.0059	1.0563	62.67	0.0021	1.2870			
54.83	0.0059	1.0622	62.83	0.0017	1.2887			
55.00	0.0058	1.0680	63.00	0.0013	1.2900			
55.17	0.0057	1.0737	63.17	0.0009	1.2909			
55.33	0.0056	1.0793	63.33	0.0005	1.2914			
55.50	0.0055	1.0848	63.50	0.0001	1.2915			
55.67	0.0055	1.0903	63.67	0.0000	1.2915			
55.83	0.0055	1.0958	63.83	0.0000	1.2915			
56.00	0.0055	1.1013	64.00	0.0000	1.2915			

Table B-5. Dimensionless Ordinates of 24-Hour Design Storm.

DIMENSIONLESS ORDINATES OF 24-HOUR DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
0.00	0.0000	0.0000	7.17	0.0080	0.2596	14.17	0.0072	0.6769
0.17	0.0036	0.0036	7.33	0.0082	0.2678	14.33	0.0072	0.6841
0.33	0.0038	0.0074	7.50	0.0084	0.2762	14.50	0.0072	0.6913
0.50	0.0040	0.0114	7.67	0.0088	0.2850	14.67	0.0071	0.6984
0.67	0.0042	0.0156	7.83	0.0093	0.2943	14.83	0.0071	0.7055
0.83	0.0045	0.0201	8.00	0.0099	0.3042	15.00	0.0070	0.7125
1.00	0.0047	0.0248	8.17	0.0102	0.3144	15.17	0.0070	0.7195
1.17	0.0048	0.0296	8.33	0.0104	0.3248	15.33	0.0069	0.7264
1.33	0.0049	0.0345	8.50	0.0107	0.3355	15.50	0.0068	0.7332
1.50	0.0049	0.0394	8.67	0.0114	0.3469	15.67	0.0067	0.7399
1.67	0.0049	0.0443	8.83	0.0127	0.3596	15.83	0.0066	0.7465
1.83	0.0050	0.0493	9.00	0.0142	0.3738	16.00	0.0065	0.7530
2.00	0.0051	0.0544	9.17	0.0220	0.3958	16.17	0.0064	0.7594
2.17	0.0051	0.0595	9.33	0.0290	0.4248	16.33	0.0063	0.7657
2.33	0.0053	0.0648	9.50	0.0160	0.4408	16.50	0.0062	0.7719
2.50	0.0053	0.0701	9.67	0.0127	0.4535	16.67	0.0060	0.7779
2.67	0.0054	0.0755	9.83	0.0116	0.4651	16.83	0.0059	0.7838
2.83	0.0054	0.0809	10.00	0.0110	0.4761	17.00	0.0059	0.7897
3.00	0.0054	0.0863	10.17	0.0106	0.4867	17.17	0.0058	0.7955
3.17	0.0055	0.0918	10.33	0.0102	0.4969	17.33	0.0057	0.8012
3.33	0.0055	0.0973	10.50	0.0096	0.5065	17.50	0.0056	0.8068
3.50	0.0056	0.1029	10.67	0.0089	0.5154	17.67	0.0055	0.8123
3.67	0.0057	0.1086	10.83	0.0085	0.5239	17.83	0.0055	0.8178
3.83	0.0058	0.1144	11.00	0.0083	0.5322	18.00	0.0055	0.8233
4.00	0.0060	0.1204	11.17	0.0082	0.5404	18.17	0.0055	0.8288
4.17	0.0062	0.1266	11.33	0.0081	0.5485	18.33	0.0054	0.8342
4.33	0.0064	0.1330	11.50	0.0080	0.5565	18.50	0.0054	0.8396
4.50	0.0066	0.1396	11.67	0.0079	0.5644	18.67	0.0054	0.8450
4.67	0.0068	0.1464	11.83	0.0078	0.5722	18.83	0.0053	0.8503
4.83	0.0069	0.1533	12.00	0.0078	0.5800	19.00	0.0053	0.8556
5.00	0.0070	0.1603	12.17	0.0077	0.5877	19.17	0.0053	0.8609
5.17	0.0072	0.1675	12.33	0.0077	0.5954	19.33	0.0053	0.8662
5.33	0.0072	0.1747	12.50	0.0076	0.6030	19.50	0.0052	0.8714
5.50	0.0073	0.1820	12.67	0.0076	0.6106	19.67	0.0052	0.8766
5.67	0.0074	0.1894	12.83	0.0075	0.6181	19.83	0.0052	0.8818
5.83	0.0075	0.1969	13.00	0.0075	0.6256	20.00	0.0052	0.8870
6.00	0.0076	0.2045	13.17	0.0074	0.6330	20.17	0.0052	0.8922
6.17	0.0077	0.2122	13.33	0.0074	0.6404	20.33	0.0051	0.8973
6.33	0.0078	0.2200	13.50	0.0074	0.6478	20.50	0.0051	0.9024
6.50	0.0078	0.2278	13.67	0.0073	0.6551	20.67	0.0051	0.9075

Table B-5 (continued). Dimensionless Ordinates of 24-Hour Design Storm.

DIMENSIONLESS ORDINATES OF 24-HOUR DESIGN STORM								
ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE	ELAPSED TIME (Hr)	INCRM ORDINATE	SUM ORDINATE
6.67	0.0079	0.2357	13.83	0.0073	0.6624	20.83	0.0050	0.9125
6.83	0.0079	0.2436	14.00	0.0073	0.6697	21.00	0.0050	0.9175
7.00	0.0080	0.2516						
21.17	0.0050	0.9225						
21.33	0.0050	0.9275						
21.50	0.0049	0.9324						
21.67	0.0049	0.9373						
21.83	0.0049	0.9422						
22.00	0.0049	0.9471						
22.17	0.0048	0.9519						
22.33	0.0048	0.9567						
22.50	0.0048	0.9615						
22.67	0.0047	0.9662						
22.83	0.0046	0.9708						
23.00	0.0045	0.9753						
23.17	0.0044	0.9797						
23.33	0.0043	0.9840						
23.50	0.0042	0.9882						
23.67	0.0041	0.9923						
23.83	0.0039	0.9962						
24.00	0.0038	1.0000						

Appendix C –

Precipitation Magnitude-Frequency Estimates for SPU Rain Gage Locations (up to 2003 data only)

Appendix C - Precipitation Magnitude-Frequency Estimates for SPU Rain Gage Locations (up to 2003 data only)

This appendix contains adapted text and excerpted tables and figures from *Analysis of Precipitation-Frequency and Storm Characteristics for the City of Seattle* (MGS Engineering Consultants, Inc. for Seattle Public Utilities, December 2003). The analysis presented here is from rain gage data ending in 2003. Analysis of data from later years was not available at the time of publication of the 2008 Directors' Rules. Updated information may be obtained from the SPU Rain Gage Network Data Steward as it becomes available.

The results of homogeneity analyses indicate that at-site mean values for precipitation do not vary across the Seattle Metropolitan Area for durations of 3 hours and less. Accordingly, one set of intensity-duration-frequency (IDF) curves can be developed that are applicable to the Seattle Metropolitan Area. Table 5 and Figures 15a and 15b provide precipitation intensities and IDF curves representative of the Seattle Metropolitan Area for durations from 5 to 180 minutes.

Table 5. Intensity-Duration-Frequency Values for Durations from 5-Minutes through 180-Minutes for Selected Recurrence Intervals for the Seattle Metropolitan Area.

DURATION (minutes)	PRECIPITATION INTENSITIES (in/hr)							
	RECURRENCE INTERVAL (Years)							
	6-Month	2-YR	5-YR	10-YR	20-YR	25-YR	50-YR	100-YR
5	1.01	1.60	2.08	2.45	2.92	3.08	3.61	4.20
6	0.92	1.45	1.87	2.21	2.62	2.76	3.23	3.75
8	0.80	1.24	1.59	1.87	2.21	2.32	2.71	3.13
10	0.71	1.10	1.40	1.64	1.93	2.03	2.36	2.72
12	0.65	1.00	1.27	1.48	1.74	1.82	2.11	2.43
15	0.58	0.88	1.12	1.30	1.52	1.60	1.84	2.11
20	0.50	0.75	0.95	1.10	1.28	1.34	1.54	1.76
25	0.45	0.67	0.84	0.97	1.12	1.18	1.35	1.53
30	0.41	0.61	0.76	0.87	1.01	1.05	1.21	1.37
35	0.38	0.56	0.69	0.80	0.92	0.96	1.10	1.24
40	0.35	0.52	0.64	0.74	0.85	0.89	1.01	1.14
45	0.33	0.49	0.60	0.69	0.79	0.83	0.94	1.06
50	0.32	0.46	0.57	0.65	0.74	0.78	0.88	0.99
55	0.30	0.44	0.54	0.61	0.70	0.73	0.83	0.94
60	0.29	0.42	0.51	0.58	0.67	0.70	0.79	0.89
65	0.28	0.40	0.49	0.56	0.64	0.66	0.75	0.84
70	0.27	0.38	0.47	0.53	0.61	0.64	0.72	0.80
80	0.25	0.36	0.43	0.49	0.56	0.59	0.66	0.74
90	0.24	0.33	0.41	0.46	0.52	0.55	0.62	0.69
100	0.22	0.32	0.38	0.43	0.49	0.51	0.58	0.64
120	0.20	0.29	0.35	0.39	0.44	0.46	0.52	0.57
140	0.19	0.26	0.32	0.36	0.40	0.42	0.47	0.52
160	0.18	0.24	0.29	0.33	0.37	0.39	0.43	0.48
180	0.17	0.23	0.27	0.31	0.35	0.36	0.40	0.45

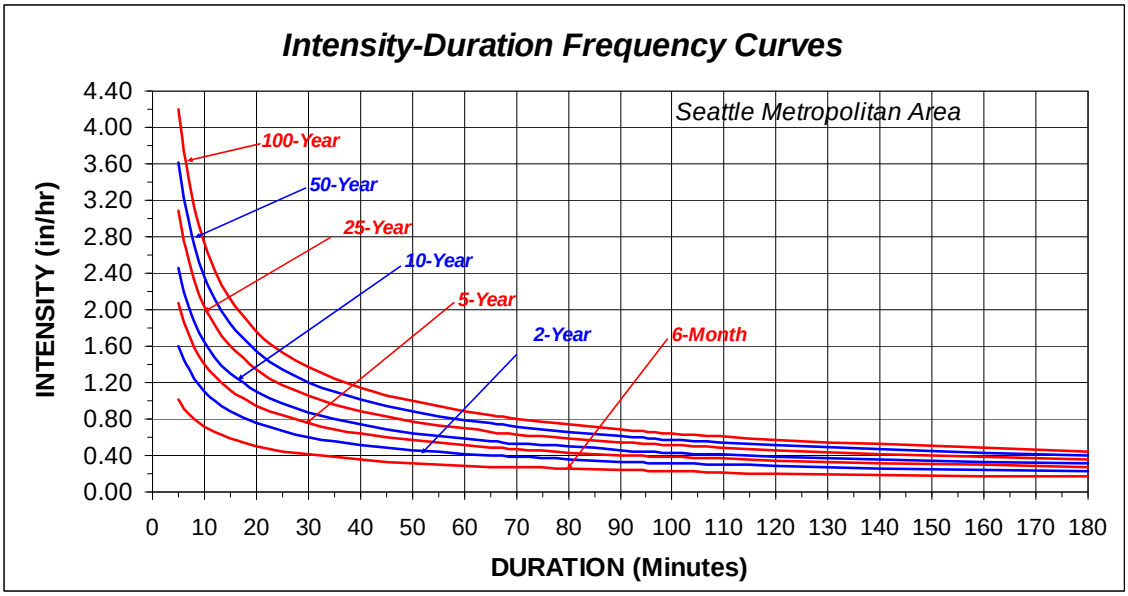

Figure 15a. Intensity-Duration-Frequency Curves for the Seattle Metropolitan Area.

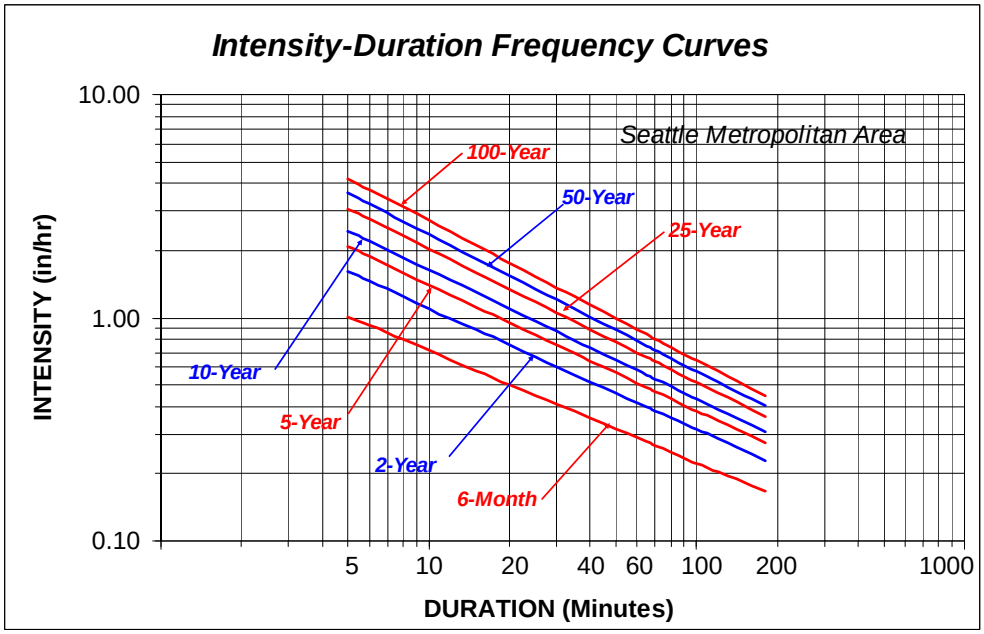

Figure 15b. Intensity-Duration-Frequency Curves for the Seattle Metropolitan Area.

The following tables and figures contain estimates of precipitation-frequency values for durations of 6 hours, 12 hours, 24 hours, 48 hours, and 7 days for locations of SPU precipitation gages (Table E-1a) in both tabular format and as magnitude-frequency curves. These precipitation values are based on estimates of the at-site mean values for the location of SPU gages (Table E-1b) based on the spatial analysis of precipitation (gridded datasets) and the applicable regional growth curves obtained from the regional frequency analyses. Corrections have been applied to provide equivalent partial duration series estimates for frequently occurring events (5 times/year, 2 times/year, once/year, 2-year, and 5-year recurrence intervals).

Table E-1a. Listing of City of Seattle (SPU) Precipitation Gages.

Station ID	Station Name	Latitude	Longitude	Year Start	Year End	Gage Type
45-S001	Haller Lake Shop	47.7211	122.3431	1965	2003	TB
45-S002	Mathews Beach Pump Station	47.6950	122.2731	1969	2003	TB
45-S003	UW Hydraulics Lab	47.6481	122.3081	1965	2003	TB
45-S004	Maple Leaf Reservoir	47.6900	122.3119	1965	2003	TB
45-S005	Fauntleroy Ferry Dock	47.5231	122.3919	1968	2003	TB
45-S007	Whitman Middle School	47.6961	122.3769	1965	2003	TB
45-S008	Ballard Locks	47.6650	122.3969	1965	2003	TB
45-S009	Woodland Park Zoo	47.6681	122.3539	1965	2003	TB
45-S010	Rainier Ave Elementary	47.5000	122.2600	1968	2003	TB
45-S011	Metro-KC Denny Regulating	47.6169	122.3550	1970	2003	TB
45-S012	Catherine Blaine Jr	47.6419	122.3969	1965	2003	TB
45-S014	West Seattle High School	47.5781	122.3819	1965	2003	TB
45-S015	Metro-KC Diagonal Pump	47.5619	122.3400	1965	2003	TB
45-S016	Metro-KC E Marginal Way	47.5350	122.3139	1970	2003	TB
45-S017	West Seattle Engr Shop	47.5211	122.3450	1965	2003	TB
45-S018	Hillman Engr Shop	47.5481	122.2750	1965	2003	TB
45-S020	TT Minor Elementary	47.6119	122.3069	1975	2003	TB
45-7473	Seattle Tacoma Airport	47.4500	122.3000	1965	2002	HR

Table E-1b. Listing of At-Site Mean Values for City of Seattle (SPU) Precipitation Gages.

At-Site Mean Values (in)							
Station ID	**Station Name**	**6-Hr**	**12-Hr**	**24-Hr**	**48-Hr**	**72-Hr**	**7-Day**
45-S001	Haller Lake Shop	1.00	1.44	1.87	2.56	2.91	4.10
45-S002	Mathews Beach Pump Station	1.00	1.43	1.85	2.55	2.89	4.07
45-S003	UW Hydraulics Lab	1.01	1.45	1.90	2.60	2.95	4.18
45-S004	Maple Leaf Reservoir	1.00	1.44	1.87	2.57	2.91	4.11
45-S005	Fauntleroy Ferry Dock	1.06	1.58	2.14	2.89	3.32	4.80
45-S007	Whitman Middle School	1.01	1.45	1.89	2.59	2.94	4.16
45-S008	Ballard Locks	1.03	1.50	1.99	2.71	3.08	4.41
45-S009	Woodland Park Zoo	1.01	1.45	1.89	2.59	2.94	4.16
45-S010	Rainier Ave Elementary	1.02	1.47	1.94	2.65	3.01	4.28
45-S011	Metro-KC Denny Regulating	1.01	1.46	1.91	2.61	2.97	4.21
45-S012	Catherine Blaine Jr	1.03	1.50	1.99	2.71	3.09	4.41
45-S014	West Seattle High School	1.03	1.51	2.00	2.73	3.11	4.44
45-S015	Metro-KC Diagonal Pump	1.01	1.46	1.91	2.61	2.96	4.20
45-S016	Metro-KC E Marginal Way	1.02	1.47	1.94	2.65	3.02	4.29
45-S017	West Seattle Engr Shop	1.03	1.51	2.02	2.74	3.13	4.48
45-S018	Hillman Engr Shop	1.01	1.46	1.91	2.61	2.97	4.21
45-S020	TT Minor Elementary	1.00	1.44	1.88	2.58	2.92	4.12
45-7473	Seattle Tacoma Airport	1.04	1.54	2.06	2.80	3.20	4.60

Table E-2. Precipitation-Magnitude-Frequency Estimates for of SPU Gage 01.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.75	0.88	1.02	1.20	1.33	1.48	1.52	1.67	1.82
12	0.76	1.05	1.26	1.47	1.76	1.96	2.19	2.27	2.49	2.72
24	0.93	1.32	1.61	1.91	2.31	2.61	2.94	3.04	3.37	3.71
48	1.34	1.84	2.22	2.61	3.14	3.53	3.97	4.11	4.56	5.02
72	1.53	2.11	2.53	2.97	3.56	3.98	4.47	4.62	5.10	5.58
168	2.11	3.00	3.62	4.23	5.01	5.53	6.10	6.28	6.81	7.32

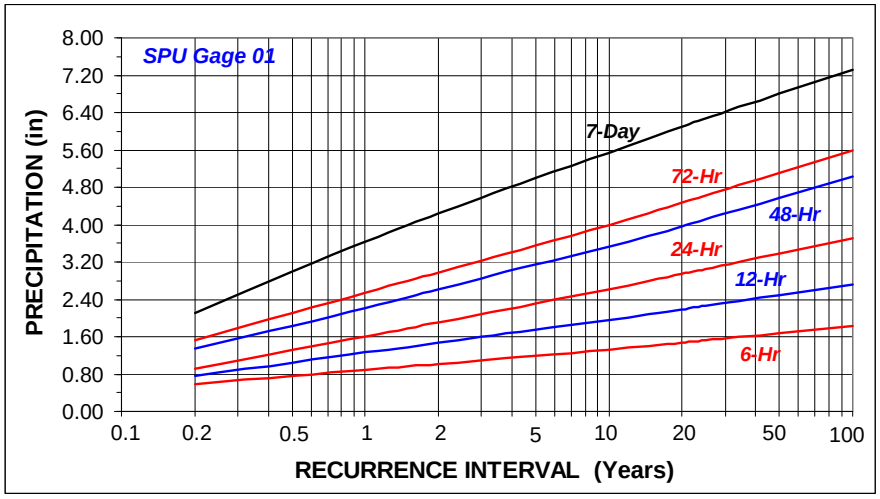

Figure E-2. Precipitation-Magnitude-Frequency Estimates for of SPU Gage 01.

Table E-3. Precipitation-Magnitude-Frequency Estimates for SPU Gage 02.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.75	0.88	1.02	1.20	1.33	1.48	1.52	1.67	1.82
12	0.76	1.04	1.25	1.46	1.75	1.95	2.18	2.25	2.48	2.70
24	0.92	1.31	1.59	1.89	2.29	2.58	2.90	3.01	3.34	3.67
48	1.33	1.83	2.21	2.60	3.13	3.51	3.95	4.10	4.55	5.00
72	1.52	2.09	2.51	2.95	3.54	3.96	4.43	4.59	5.06	5.55
168	2.09	2.98	3.60	4.20	4.97	5.49	6.06	6.23	6.76	7.27

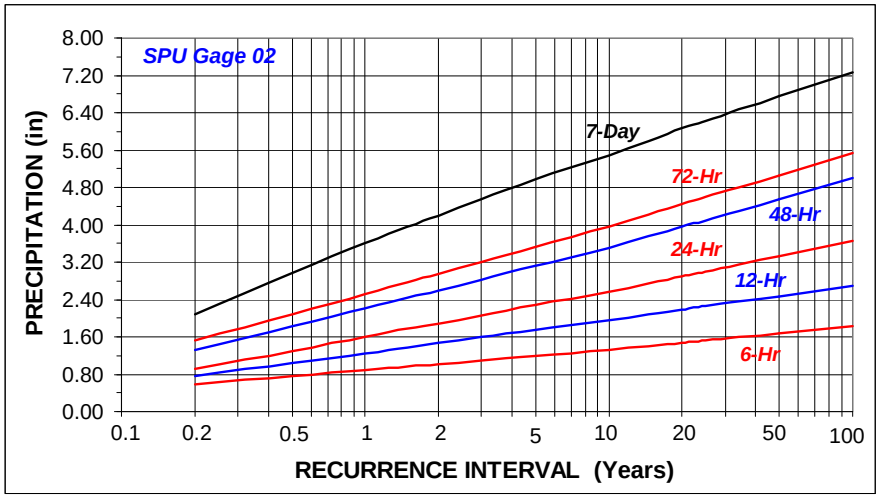

Figure E-3. Precipitation-Magnitude-Frequency Estimates for SPU Gage 02.

Table E-4. Precipitation-Magnitude-Frequency Estimates for SPU Gage 03.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.48	1.77	1.97	2.21	2.28	2.51	2.74
24	0.94	1.34	1.64	1.94	2.35	2.65	2.98	3.09	3.43	3.77
48	1.36	1.87	2.25	2.65	3.19	3.58	4.03	4.18	4.63	5.10
72	1.55	2.14	2.57	3.01	3.61	4.04	4.53	4.68	5.17	5.66
168	2.15	3.06	3.69	4.32	5.10	5.64	6.22	6.40	6.94	7.47

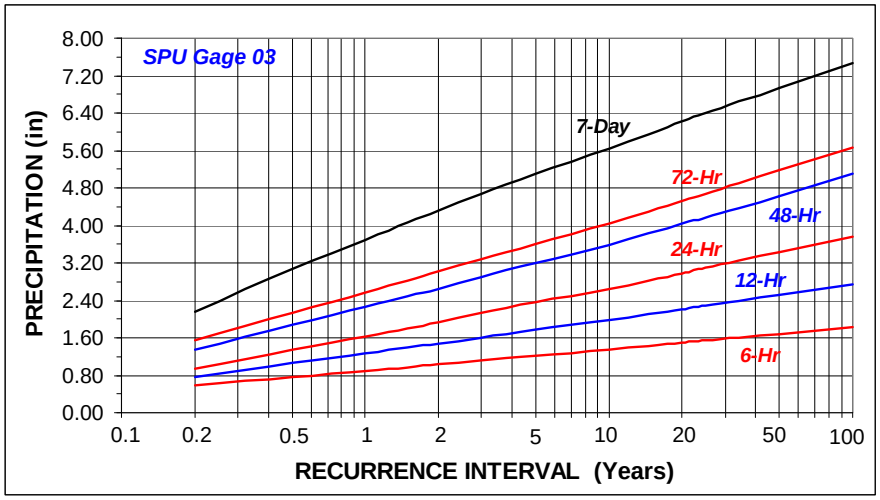

Figure E-4. Precipitation-Magnitude-Frequency Estimates for SPU Gage 03.

Table E-5. Precipitation-Magnitude-Frequency Estimates for SPU Gage 04.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.75	0.88	1.02	1.20	1.33	1.48	1.52	1.67	1.82
12	0.76	1.05	1.26	1.47	1.76	1.96	2.19	2.27	2.49	2.72
24	0.93	1.32	1.61	1.91	2.31	2.61	2.94	3.04	3.37	3.71
48	1.34	1.85	2.22	2.62	3.15	3.54	3.99	4.13	4.58	5.04
72	1.53	2.11	2.53	2.97	3.56	3.98	4.47	4.62	5.10	5.58
168	2.11	3.01	3.63	4.24	5.02	5.55	6.12	6.29	6.83	7.34

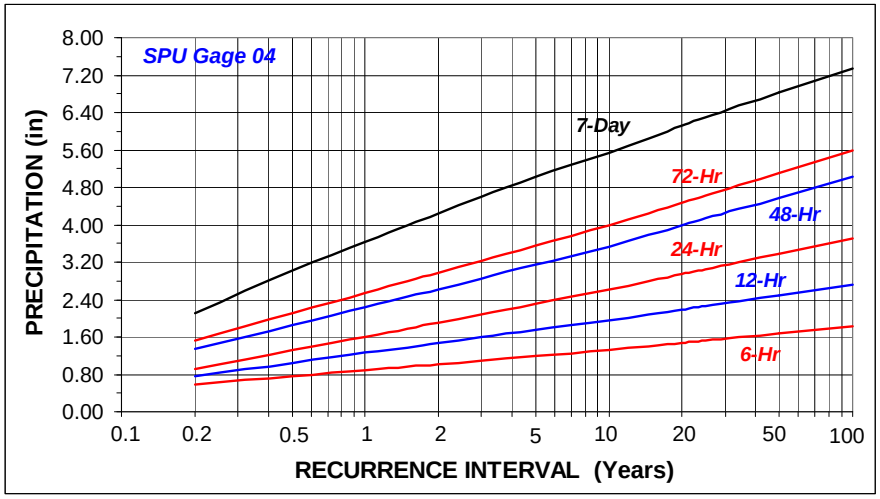

Figure E-5. Precipitation-Magnitude-Frequency Estimates for SPU Gage 04.

Table E-6. Precipitation-Magnitude-Frequency Estimates for SPU Gage 05.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.61	0.80	0.94	1.08	1.27	1.41	1.57	1.62	1.77	1.93
12	0.84	1.15	1.38	1.61	1.93	2.15	2.40	2.49	2.74	2.99
24	1.06	1.51	1.84	2.19	2.65	2.98	3.36	3.48	3.86	4.24
48	1.51	2.08	2.50	2.94	3.54	3.98	4.48	4.64	5.15	5.67
72	1.74	2.40	2.89	3.39	4.06	4.55	5.09	5.27	5.82	6.37
168	2.47	3.52	4.24	4.96	5.86	6.48	7.14	7.35	7.97	8.57

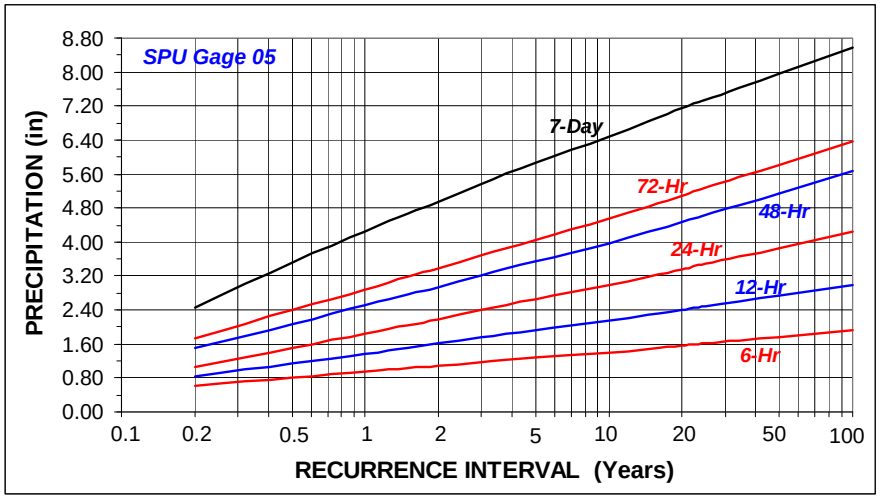

Figure E-6. Precipitation-Magnitude-Frequency Estimates for SPU Gage 05.

Table E-7. Precipitation-Magnitude-Frequency Estimates for SPU Gage 07.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.48	1.77	1.97	2.21	2.28	2.51	2.74
24	0.94	1.33	1.63	1.93	2.34	2.63	2.97	3.07	3.41	3.75
48	1.35	1.86	2.24	2.64	3.18	3.57	4.02	4.16	4.62	5.08
72	1.54	2.13	2.56	3.00	3.60	4.03	4.51	4.67	5.15	5.64
168	2.14	3.05	3.68	4.30	5.08	5.61	6.19	6.37	6.91	7.43

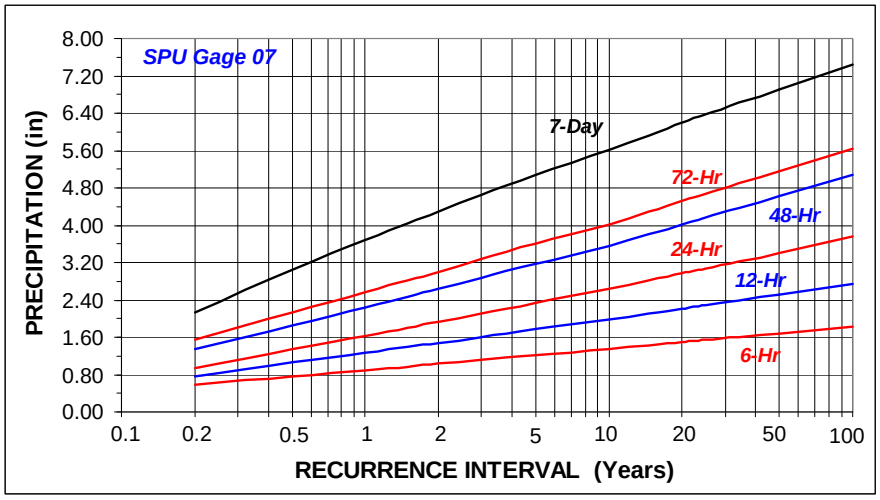

Figure E-7. Precipitation-Magnitude-Frequency Estimates for SPU Gage 07.

Table E-8. Precipitation-Magnitude-Frequency Estimates for SPU Gage 08.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.78	0.91	1.05	1.24	1.37	1.52	1.57	1.72	1.87
12	0.80	1.09	1.31	1.53	1.83	2.04	2.28	2.36	2.60	2.84
24	0.98	1.41	1.71	2.03	2.46	2.77	3.12	3.24	3.59	3.94
48	1.41	1.95	2.35	2.76	3.32	3.73	4.20	4.35	4.83	5.32
72	1.62	2.23	2.68	3.14	3.77	4.22	4.73	4.89	5.40	5.91
168	2.27	3.23	3.90	4.55	5.39	5.95	6.56	6.75	7.33	7.88

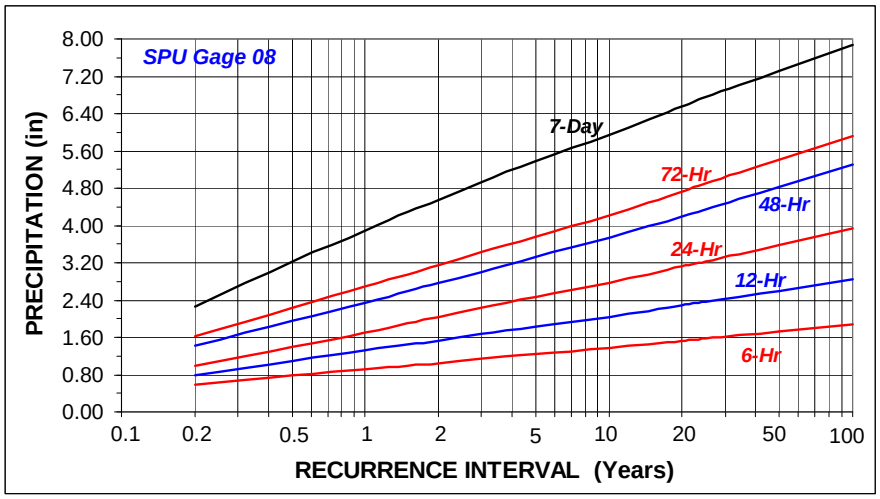

Figure E-8. Precipitation-Magnitude-Frequency Estimates for SPU Gage 08.

Table E-9. Precipitation-Magnitude-Frequency Estimates for SPU Gage 09.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.48	1.77	1.97	2.21	2.28	2.51	2.74
24	0.94	1.33	1.63	1.93	2.34	2.63	2.97	3.07	3.41	3.75
48	1.35	1.86	2.24	2.64	3.18	3.57	4.02	4.16	4.62	5.08
72	1.54	2.13	2.56	3.00	3.60	4.03	4.51	4.67	5.15	5.64
168	2.14	3.05	3.68	4.30	5.08	5.61	6.19	6.37	6.91	7.43

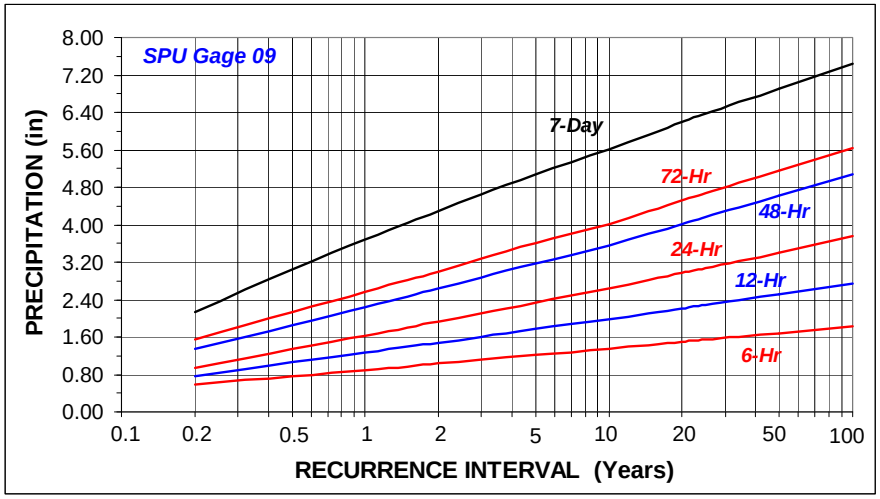

Figure E-9. Precipitation-Magnitude-Frequency Estimates for SPU Gage 09.

Table E-10. Precipitation-Magnitude-Frequency Estimates for SPU Gage 10.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.77	0.90	1.04	1.22	1.36	1.51	1.55	1.70	1.86
12	0.78	1.07	1.28	1.50	1.79	2.00	2.24	2.31	2.55	2.78
24	0.96	1.37	1.67	1.98	2.40	2.70	3.05	3.16	3.50	3.85
48	1.38	1.91	2.29	2.70	3.25	3.65	4.11	4.26	4.72	5.20
72	1.58	2.18	2.62	3.07	3.68	4.12	4.62	4.78	5.27	5.78
168	2.20	3.14	3.78	4.42	5.23	5.78	6.37	6.55	7.11	7.64

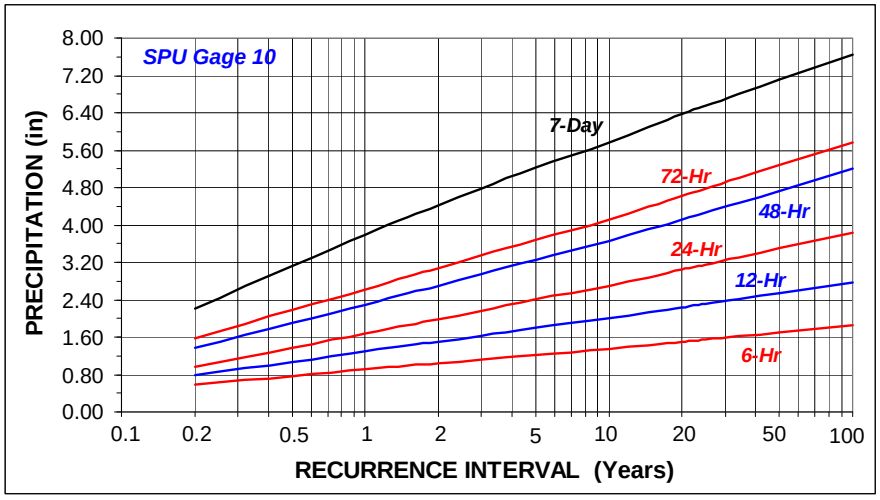

Figure E-10. Precipitation-Magnitude-Frequency Estimates for SPU Gage 10.

Table E-11. Precipitation-Magnitude-Frequency Estimates for SPU Gage 11.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.49	1.78	1.99	2.22	2.30	2.53	2.76
24	0.95	1.35	1.64	1.95	2.36	2.66	3.00	3.11	3.44	3.79
48	1.36	1.88	2.26	2.66	3.20	3.60	4.05	4.19	4.65	5.12
72	1.56	2.15	2.58	3.03	3.63	4.07	4.56	4.71	5.20	5.70
168	2.16	3.08	3.72	4.35	5.14	5.68	6.27	6.45	6.99	7.52

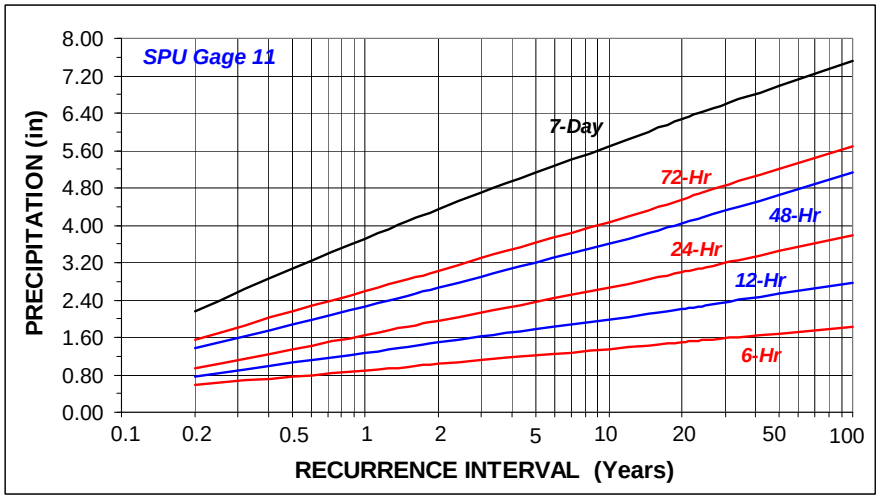

Figure E-11. Precipitation-Magnitude-Frequency Estimates for SPU Gage 11.

Table E-12. Precipitation-Magnitude-Frequency Estimates for SPU Gage 12.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.78	0.91	1.05	1.24	1.37	1.52	1.57	1.72	1.87
12	0.80	1.09	1.31	1.53	1.83	2.04	2.28	2.36	2.60	2.84
24	0.98	1.41	1.71	2.03	2.46	2.77	3.12	3.24	3.59	3.94
48	1.41	1.95	2.35	2.76	3.32	3.73	4.20	4.35	4.83	5.32
72	1.62	2.24	2.69	3.16	3.78	4.23	4.74	4.90	5.41	5.93
168	2.27	3.23	3.90	4.55	5.39	5.95	6.56	6.75	7.33	7.88

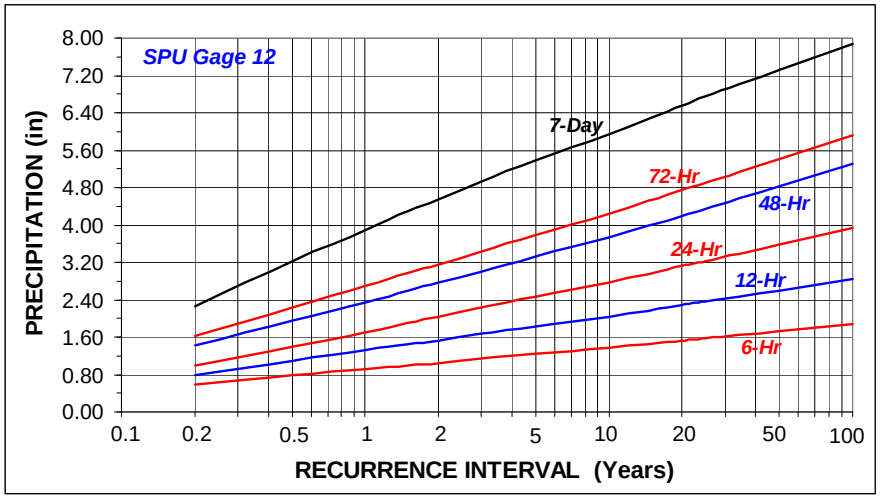

Figure E-12. Precipitation-Magnitude-Frequency Estimates for SPU Gage 12.

Table E-13. Precipitation-Magnitude-Frequency Estimates for SPU Gage 14.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.78	0.91	1.05	1.24	1.37	1.52	1.57	1.72	1.87
12	0.80	1.10	1.32	1.54	1.84	2.06	2.30	2.38	2.61	2.86
24	0.99	1.41	1.72	2.04	2.48	2.79	3.14	3.25	3.61	3.96
48	1.42	1.96	2.36	2.78	3.35	3.76	4.23	4.39	4.87	5.36
72	1.63	2.25	2.71	3.18	3.81	4.26	4.77	4.94	5.45	5.97
168	2.28	3.25	3.92	4.58	5.42	5.99	6.61	6.80	7.38	7.93

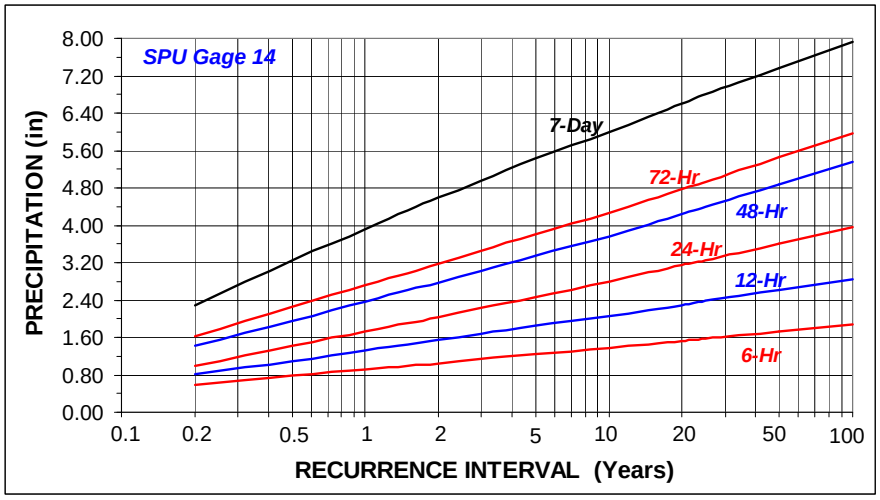

Figure E-13. Precipitation-Magnitude-Frequency Estimates for SPU Gage 14.

Table E-14. Precipitation-Magnitude-Frequency Estimates for SPU Gage 15.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.49	1.78	1.99	2.22	2.30	2.53	2.76
24	0.95	1.35	1.64	1.95	2.36	2.66	3.00	3.11	3.44	3.79
48	1.36	1.88	2.26	2.66	3.20	3.60	4.05	4.19	4.65	5.12
72	1.55	2.14	2.58	3.02	3.62	4.05	4.54	4.70	5.19	5.68
168	2.16	3.08	3.71	4.34	5.13	5.67	6.25	6.43	6.98	7.50

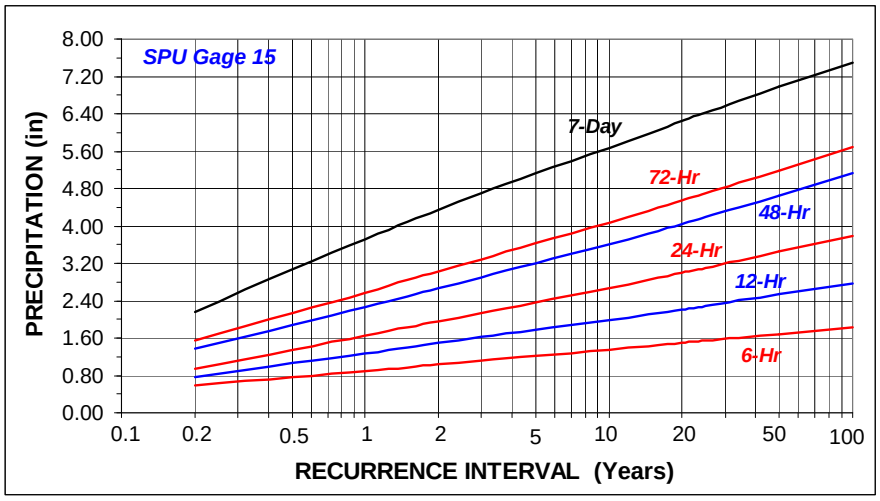

Figure E-14. Precipitation-Magnitude-Frequency Estimates for SPU Gage 15.

Table E-15. Precipitation-Magnitude-Frequency Estimates for SPU Gage 16.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.77	0.90	1.04	1.22	1.36	1.51	1.55	1.70	1.86
12	0.78	1.07	1.28	1.50	1.79	2.00	2.24	2.31	2.55	2.78
24	0.96	1.37	1.67	1.98	2.40	2.70	3.05	3.16	3.50	3.85
48	1.38	1.91	2.29	2.70	3.25	3.65	4.11	4.26	4.72	5.20
72	1.58	2.19	2.63	3.08	3.70	4.13	4.63	4.79	5.29	5.80
168	2.20	3.14	3.79	4.43	5.24	5.79	6.39	6.57	7.13	7.66

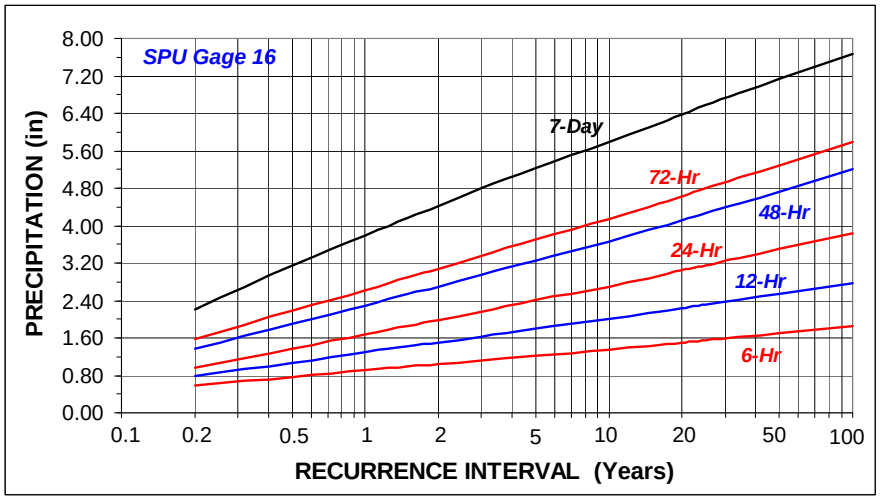

Figure E-15. Precipitation-Magnitude-Frequency Estimates for SPU Gage 16.

Table E-16. Precipitation-Magnitude-Frequency Estimates for SPU Gage 17.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.59	0.78	0.91	1.05	1.24	1.37	1.52	1.57	1.72	1.87
12	0.80	1.10	1.32	1.54	1.84	2.06	2.30	2.38	2.61	2.86
24	1.00	1.43	1.74	2.06	2.50	2.81	3.17	3.29	3.64	4.00
48	1.43	1.97	2.37	2.79	3.36	3.77	4.25	4.40	4.88	5.37
72	1.64	2.27	2.72	3.20	3.83	4.29	4.80	4.97	5.49	6.01
168	2.30	3.28	3.96	4.63	5.47	6.05	6.67	6.86	7.44	8.00

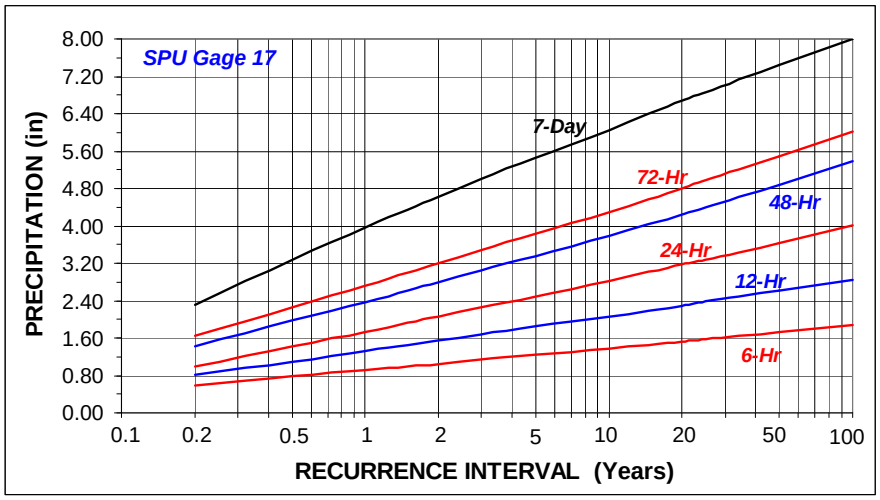

Figure E-16. Precipitation-Magnitude-Frequency Estimates for SPU Gage 17.

Table E-17. Precipitation-Magnitude-Frequency Estimates for SPU Gage 18.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.76	0.89	1.03	1.21	1.34	1.49	1.54	1.69	1.84
12	0.77	1.06	1.27	1.49	1.78	1.99	2.22	2.30	2.53	2.76
24	0.95	1.35	1.64	1.95	2.36	2.66	3.00	3.11	3.44	3.79
48	1.36	1.88	2.26	2.66	3.20	3.60	4.05	4.19	4.65	5.12
72	1.56	2.15	2.58	3.03	3.63	4.07	4.56	4.71	5.20	5.70
168	2.16	3.08	3.72	4.35	5.14	5.68	6.27	6.45	6.99	7.52

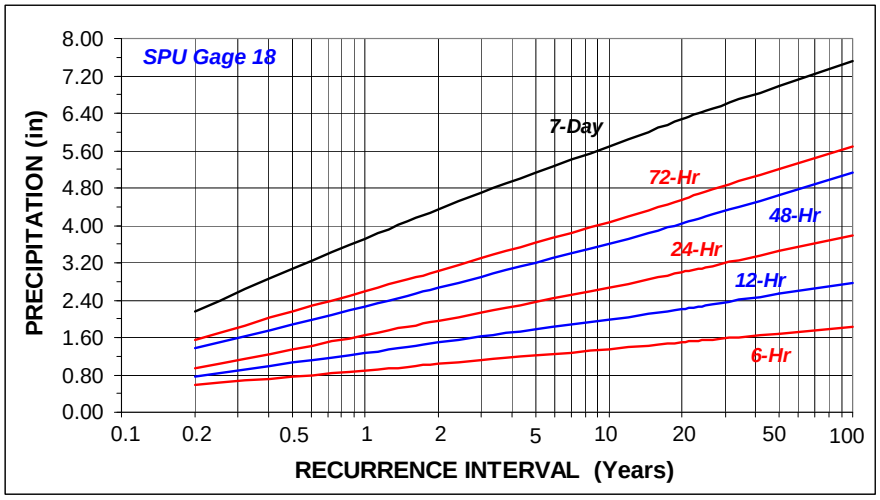

Figure E-17. Precipitation-Magnitude-Frequency Estimates for SPU Gage 18.

Table E-18. Precipitation-Magnitude-Frequency Estimates for SPU Gage 20.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.58	0.75	0.88	1.02	1.20	1.33	1.48	1.52	1.67	1.82
12	0.76	1.05	1.26	1.47	1.76	1.96	2.19	2.27	2.49	2.72
24	0.93	1.33	1.62	1.92	2.33	2.62	2.95	3.06	3.39	3.73
48	1.35	1.86	2.23	2.63	3.16	3.55	4.00	4.15	4.60	5.06
72	1.53	2.11	2.54	2.98	3.57	4.00	4.48	4.64	5.12	5.60
168	2.12	3.02	3.64	4.25	5.03	5.56	6.13	6.31	6.84	7.36

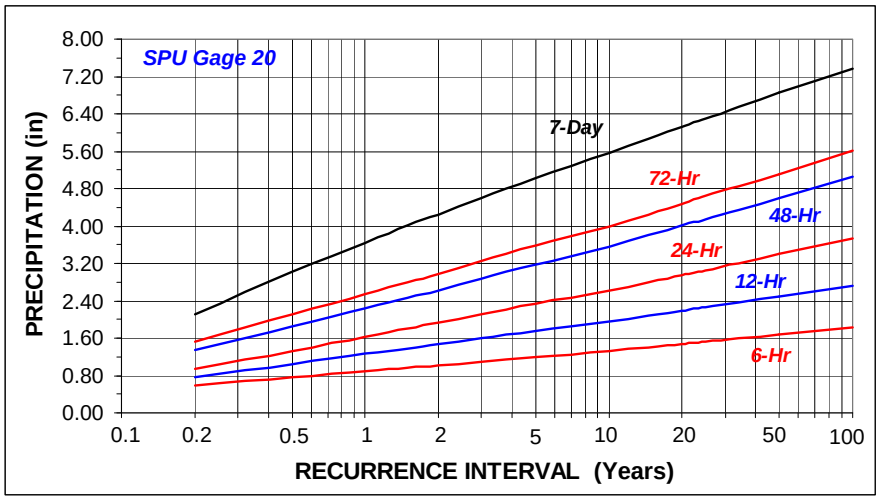

Figure E-18. Precipitation-Magnitude-Frequency Estimates for SPU Gage 20.

Table E-19. Precipitation-Magnitude-Frequency Estimates for SeaTac.

Duration (hr)	Precipitation (in)									
	Recurrence Interval (years)									
	0.2-Yr	0.5-Yr	1-Yr	2-Yr	5-Yr	10-Yr	20-Yr	25-Yr	50-Yr	100-Yr
6	0.60	0.78	0.92	1.06	1.25	1.38	1.54	1.58	1.74	1.89
12	0.82	1.12	1.34	1.57	1.88	2.10	2.34	2.42	2.67	2.91
24	1.02	1.45	1.77	2.11	2.55	2.87	3.23	3.35	3.72	4.08
48	1.46	2.01	2.42	2.85	3.43	3.86	4.34	4.50	4.99	5.49
72	1.68	2.32	2.78	3.27	3.92	4.38	4.91	5.08	5.61	6.14
168	2.36	3.37	4.06	4.75	5.62	6.21	6.85	7.04	7.64	8.22

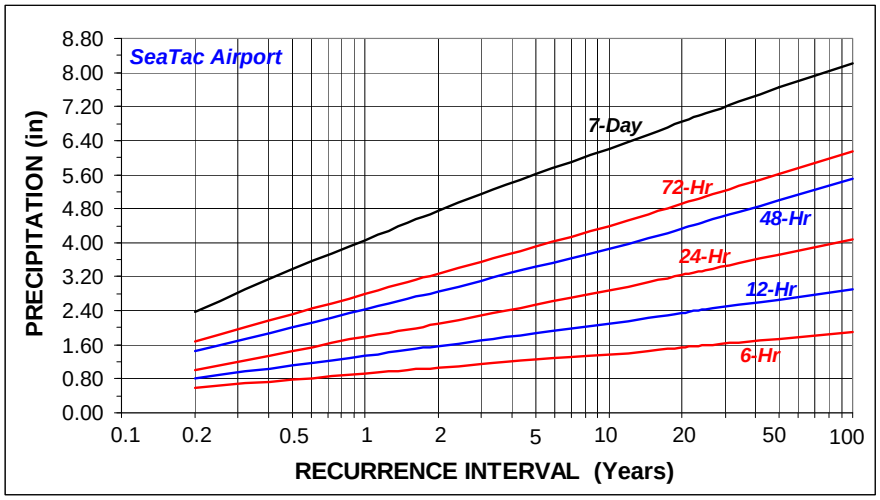

Figure E-19. Precipitation-Magnitude-Frequency Estimates for SeaTac.

Appendix D –

Facility Operations and Maintenance Requirements

Appendix D - Facility Operations and Maintenance Requirements

This appendix outlines inspection, maintenance, and record keeping requirements for stormwater management facilities installed for Stormwater Code compliance in the City of Seattle. See SMC 22.803.020.C, 22.803.020.D, 22.803.020.E, 22.805.020.D.13, 22.805.080.C, 22.805.090.C, and 22.807.090.

The types of drainage facilities covered in this appendix include:

- Catch basins, maintenance holes, and storm drain inlets
- Vaults, tanks, and pipes
- Oil/water separators
- Media filters
- Biofilters (swales, wet swales, and filter strips)
- Infiltration trenches, drywells and infiltration basins
- Ponds and constructed wetlands
- Bioretention facilities
- Permeable pavement
- Green roofs
- Cisterns
- Compost amended soil
- Trees
- Operation and Maintenance Requirements for Single Family Residential Projects

Also provided in the appendix is the following:

- Schedule of Continuing Responsibility for Green Stormwater Infrastructure in Public Right-of-Ways

The appendix is designed to serve as both a statement of maintenance requirements as well as an inspection checklist for responsible parties. The tables presented below list the inspection and maintenance requirements for each system. These requirements include information about what features must be inspected, when and how often these systems must be inspected, and how to identify specific defects that require corrective action to maintain system performance.

At a minimum, responsible parties are required to inspect stormwater facilities at the inspection frequencies listed in the checklists. Some facility items must be inspected twice during the wet season, while other items must be inspected only once each year during the dry season. If the condition of any of the facilities during inspection triggers a requirement for maintenance, then the responsible parties must make the necessary repairs described on the checklist.

Responsible parties are required to maintain records of inspection and maintenance actives (SMC 22.803.020.E). While it is not required that the checklists included in this appendix be used for this purpose, the documentation must include information that is substantially equivalent to what is presented in the checklists. The records must be maintained on file to document that the necessary inspections and maintenance have been completed. City surface water quality inspectors will review these records when checking private systems to see that they are being adequately maintained.

For surface stormwater facilities placed in the public right-of-way, including bioretention and permeable pavements, the City will place additional requirements on project proponents (see Section D.16). The level of service described in this appendix is functional, not aesthetic.

D.1 Catch Basins, Maintenance Holes, and Storm Drain Inlets

Grated and curb-inlet type catch basins are designed to collect and direct runoff into the storm drainage system, as well as to trap debris and litter present in roadway runoff. Unlike maintenance holes and inlets, catch basins contain a sump at the bottom of the structure to collect sediment and other debris. The purpose of the sump is to prevent the downstream pipes from becoming clogged and to prevent sediment and debris from being discharged into receiving waters. In addition, the outlet pipe on catch basins in Seattle is typically installed with a downturned elbow or tee to trap floatable material.

Field personnel performing inspections of catch basins, maintenance holes, and inlets must use the checklist below as the foundation for their inspections. However, on sites with multiple catch basin, maintenance hole, and inlet facilities, inspectors are encouraged to develop additional summary tables or support documentation to enable them to efficiently and accurately record the range of maintenance needs identified for the multiple on-site facilities.

Inspection and Maintenance Requirements for Catch Basins, Maintenance Holes, and Inlets

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Cleaning						
Standing water	As needed	Standing water present during maintenance activities	Remove/dispose with other material in accordance with state and federal regulations. Do not pump to downstream stormwater system.			
Trash, debris, sediment, vegetation	A[2]	Accumulated material within 18 inches of the bottom of the lowest pipe entering or exiting the structure or filling greater than 60 percent of the sump depth.	Remove/dispose in accordance with state and federal regulations.			
	A	Sediment, debris, or vegetation blocking 1/2 capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	B, W, E	Vegetation/debris blocking 10 percent or more of inlet capacity.	Clean and dispose of material			
	A	Dead animals or vegetation that could generate odors and cause complaints or dangerous gases (e.g., methane).	Remove/dispose			
Pollution	A[2], E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source			
Structure						
Frame and/or top slab	A	Corner extends more than 0.75 inches past curb face or street surface (where applicable).	Repair so frame even with curb			
	A	Holes greater than 2 inches or cracks greater than 0.25 inches in top slab.	Repair to water tight condition			
	A	Frame not flush with top slab (separation >0.75 inches) or not securely attached.	Repair			

Inspection and Maintenance Requirements for Catch Basins, Maintenance Holes, and Inlets (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Structure *(continued)*						
CB structure	A	Cracks wider than 0.5 inches and longer than 1 foot, missing bricks, evidence of water of soil entering, or judged to be structurally unsound by maintenance personnel.	Repair			
	A	Cracks wider than 0.5 inches and longer than 1 foot at pipe inlet/outlet.	Repair			
Cover/grate	A	Cover/grate missing, damaged, or only partially in place.	Repair/replace			
	A	Grate openings are wider than 7/8 inch.	Replace			
	A	Cannot be opened by one person. Locking bolts missing, damaged, or have less than ½ inch of thread.	Repair/replace			
	A	Buried.	Expose and restore to surface grade.			
Ladder	A	Ladder rungs damaged, missing, or misaligned.	Repair/replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

[2] Minimum requirement is for annual inspections. More frequent inspections and maintenance may be required depending on site conditions.

D.2 Vaults, Tanks, and Pipes

Vaults, tanks, and pipes are underground storage facilities that can be designed as dry systems (i.e., detention for flow control), wet systems for water quality treatment, or as combined systems that provide both flow and water quality control. Underground facilities are generally used to manage storm water from smaller sites (e.g., less than 5 acres). Vaults are typically constructed of reinforced concrete, while tanks and pipes are usually made of corrugated metal or plastic pipe.

In Seattle, dry vaults/tanks (i.e., detention) are most common. Detention systems are designed primarily to control the rate of runoff from developed sites. Runoff enters the vault or tank and is temporarily stored as water is slowly released through a small orifice to the downstream drainage system. Detention storage is often referred to as “live” storage. Controlling peak discharge rates from developed sites reduces stream bank erosion and minimizes flooding in downstream areas. Detention vaults/tanks are designed to drain completely dry following storm events.

Wet vaults/tanks contain a permanent pool (i.e., wet pool) that functions as an energy dissipater, slowing the velocity of incoming storm water and allowing suspended sediment to settle. The permanent pool volume is generally referred to as “dead” storage. Wet vaults/tanks typically provide no live storage for flow control purposes and function only as water treatment devices.

Combined systems simply incorporate the live storage of a dry vault/tank with the dead storage (i.e., wet pool) of a wet vault/tank into a single facility. Consequently, these facilities provide both flow control and water quality treatment.

Inspection and Maintenance Requirements for Vaults, Tanks, and Detention Pipes

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in structure)						
Standing water	As needed	Standing water present during maintenance activities	Remove/dispose with other material in accordance with state and federal regulations. Do not pump to downstream stormwater system.			
Pollution	A, E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source.			
Vault/Tank Structure						
Sediment (for detention structures)	A	Accumulated sediment in vault/tank exceeds 6 inches.	Remove/dispose in accordance with state and federal regulations.			
Sediment (for wet vaults)	A	Accumulated sediment in wet vault exceeds 18 inches.	Remove/dispose in accordance with state and federal regulations.			
Joints Between Tank/Pipe Section	A	Any openings or voids allowing material to be transported into facility.	Seal pipes and joints			
Tank Pipe Structurally Compromised	A	Recent surface defects indicating structural failure of tank such as presence of voids above pipe, curbs/gutters displaced, or pavement cracked.	Repair/replace			
Ladder	A	Ladder rungs damaged, missing, or misaligned.	Repair/replace			

Inspection and Maintenance Requirements for Vaults, Tanks, and Detention Pipes (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Vault/Tank Structure *(continued)*						
Concrete (inspect when vault cleaned)	A	Riser, concrete walls, or joints cracked or leaking. Bricks missing. Cracks greater than 0.5 inches wide or determined to be structurally unsound.	Repair			
Maintenance holes	A	Cannot be opened by one person. Locking bolts missing or damaged or less than ½ inch of thread.	Repair/replace			
	A	Buried.	Expose and restore to surface grade.			
	A	Cover missing.	Replace			
Shutoff Valve and/or Maintenance Drain (if present exercise fully and inspect)	A	Valve cannot be operated by one person. Valve rusted or not watertight.	Repair/replace			
Baffle(s)	A	Corroded, cracked, or warped.	Repair/replace			
Air vents	A	Debris blocking 10 percent or more of vent.	Clean			
Control Structure						
Sediment	A	Accumulated material within 18 inches of the bottom of the lowest pipe entering or exiting the structure or filling greater than 60 percent of the sump depth	Remove/dispose in accordance with state and federal regulations.			
Trash/debris	A	Accumulated trash/debris impedes performance of control structure.	Remove/dispose			
Structure (e.g., Riser)	A	Control structure is not securely attached.	Secure/repair			
	A	Structure is not in upright position (allow up to 10 percent from plumb).	Repair/reposition			
	A	Structure visibly damaged, crushed, broken, or otherwise deformed.	Repair/replace			
	A	Connections to outlet pipe are not watertight.	Repair/replace			
Overflow pipe	A	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Clean			

Inspection and Maintenance Requirements for Vaults, Tanks, and Detention Pipes (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Control Structure *(continued)*						
Shear gate or Cleanout gate (exercise full open/close and inspect)	A	Gate cannot be operated by 1 person.	Lubricate, repair, or replace			
	A	Gate rusted on 50 percent of structure, not watertight, or missing.	Repair/replace			
	A	Chain or pull rod missing.	Replace			
	A	Not plumb within 10 percent.	Repair			
	A	Connection to outlet pipe rusted or leaking.	Repair/replace			
Orifice plates (inspect when vault cleaned)	A	Bent, rusted, out of place, obstructed, or missing.	Repair/clean/ replace			
Outlet pipe	A	Submerged or partially submerged	Check for orifice plate blockages or downstream obstruction			
Oil absorbent pads (if present)	B,E	Must replace every 6 months.	Remove and replace			
Inlet/Outlet						
Trash rack	B, W, E	Trash or other debris present on trash rack.	Remove/dispose			
	A	Bar screen damaged or missing	Replace			
Inlet/Outlet Pipes	A	Sediment, debris, or vegetation blocking 1/3 capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Inlet/outlet piping damaged or broken and in need of repair.	Repair/replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

D.3 Oil/Water Separators

Oil/water separators are used to treat storm water runoff from high use developments that generate relatively large quantities of oil and grease (e.g., shopping centers, roadways, and parking lots). There are three types of oil/water separators: the conventional gravity API (American Petroleum Institute) separator, coalescing plate separators (CPS), and floatable material separators (FMS).

The conventional gravity API separator consists of a large vault equipped with baffles to prevent oil and other floating debris from passing through the separator. The baffles extend down vertically from the top of the vault, trapping floatable material within the vault chambers. In addition, a baffle is usually installed on the bottom at the upstream end of the vault to trap suspended sediment. Oil absorbent pads or mechanical skimmers can also be installed in the main chamber to remove separated oil.

Coalescing plate separators are similar to API separators except that a bank of closely spaced, inclined, corrugated plates is inserted into the separator chamber to improve removal efficiency. Consequently, these systems are usually smaller in size than the conventional API separator. The plates are usually constructed of fiberglass, stainless steel, or polypropylene. Because of the closely spaced configuration of the plates, sediment and other debris can easily clog these systems. Therefore, to work effectively, the coalescing plates must be kept clean.

FMS separators are simple containment devices capable of trapping floatable materials. They consist of a vault or manhole structure that is equipped with a downturned elbow on the outlet. These devices are not as effective as CPS and API separators in separating oil; they function primarily for spill containment and as floating debris traps.

Inspection and Maintenance Requirements for Oil/Water Separators

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (all types of separators)						
Discharge quality	A, E	Oil sheen, unusual color, petroleum odor.	Identify/control source			
Oil Accumulation	A, E	Oil accumulations that exceed 1 inch at the surface of the water.	Remove and dispose in accordance with state and federal regulations.			
Trash and debris	A, E	Accumulated trash/debris impedes performance.	Remove/dispose			
Sediment	A, E	Depth exceeds 6 inches or vertical space between bottom of inlet baffle and vault floor is obstructed by 50 percent or more.	Remove/dispose in accordance with state and federal regulations.			
Oil absorbent pads (if present)	B, E	Must replace every 6 months.	Remove and replace.			
Bypass valve (exercise full open/close and inspect)	A	Gate cannot be operated by one person.	Lubricate, repair, or replace			
Inlet/Outlet Pipes	A	Sediment, debris, or vegetation blocking 1/2capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Inlet/outlet piping damaged or broken and in need of repair.	Repair/replace			
Outlet pipe	A	Submerged or partially submerged	Check for orifice plate blockages or downstream obstruction			

Inspection and Maintenance Requirements for Oil/Water Separators (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Vault Structure (all types of separators)						
Ladder	A	Ladder rungs damaged, missing, or misaligned.	Repair/replace			
Concrete	Inspect when vault cleaned	Riser, concrete walls, or joints cracked or leaking. Leveling bricks (if applicable) missing. Cracks greater than 0.5 inches wide or determined to be structurally unsound.	Repair			
Maintenance holes	A	Cannot be opened by one person. Locking bolts missing or damaged or less than ½ inch of thread.	Repair/replace			
	A	Buried.	Expose and restore to surface grade.			
Baffle(s)	A	Cracked, warped, or otherwise structurally unsound.	Repair/replace			
Coalescing Plates Separators						
Sediment	A, E	Visible clogging of plates.	Clean			
Plates	A	Brittle, cracked, or deformed.	Replace			
Floatable Material Separators						
Tee section	A	Missing.	Replace			
	A	Loose, not firmly attached to manhole wall.	Repair			
	A	Not plumb within 10 percent.	Repair			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release). Separators are required to be cleaned after spills.

D.4 Media Filters

Filter systems involve passing runoff through a filtration media to remove pollutants. After treatment in the filter, runoff is collected in an underdrain system and discharged to the public drainage control system. Various media have been used, including sand, leaf compost, perlite, zeolite, and peat moss. Structures may be constructed above ground in open ponds or below ground in vaults. In proprietary technologies, filter media may be contained in canisters rather than being placed loose in the structure. This maintenance section refers only to non-proprietary, loose filter media facilities. For inspection and maintenance of proprietary media filters, to the responsible party must comply with the manufacturer's guidelines and any additional requirements specified by the Department of Ecology.

Filters require special care to prevent the filter surface from becoming clogged. Once a filter begins to clog, the hydraulic capacity drops dramatically, causing the filter to go into overflow stage much more frequently than usual. As a result, treatment performance is severely reduced. Therefore, pretreatment systems such as biofilters, wet ponds, or wet vaults are often installed immediately upstream of filtration systems to prolong the life of the filter media.

Inspection and Maintenance Requirements for Media Filters

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in facility)						
Trash/debris	A[2], E	For below ground filters, accumulated trash/debris impedes performance. For above ground filters, trash/debris exceeds 5 cubic feet (this is about equal to the amount of trash in one standard size garbage can) per 1,000 square feet. In general there should be no evidence of visual dumping.	Remove/dispose in accordance with state and federal regulations.			
Pollution	A[2], E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source.			
Pipes	A	Sediment, debris, or vegetation blocking 1/2 capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Piping damaged or broken and in need of repair.	Repair/replace			
Filter Media/Surface						
Infiltration Capacity Indicators	A[2], E	Sediment: >75 percent coverage of sediment on top of filter media surface or Standing water: Standing water 24 hours after storm event.	Perform Drawdown Test			

Inspection and Maintenance Requirements for Media Filters (continued)

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Filter Media/Surface *(continued)*						
Drawdown Test[3]	As required by Infiltration Capacity Indicators (above row)	Clogging: Filtration rate less than approximately 1 in/hr (averaged over a 4-hour period)	Scrape, rototill, aerate, remove thatch, or replace media. Inspect geotextiles for clogging.			
		Short Circuiting: Filtration rate greater than 12 in/hr (averaged over a 4-hour period)	Regrade and recompact filter surface.			
Prolonged Flows	A[2]	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Limit low, continuous flows to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.			
Short Circuiting	A[2]	Uneven/concentrated flow through media or visible erosion along sides of facility walls/embankments).	Regrade and recompact filter surface, repair level spreader			
Erosion/ scouring	A[2]	Rills/gullies more than 2 inches deep or otherwise uneven surface.	Regrade filter surface			
Flow/level spreader	A[2]	Erosion damage at inlet to media surface greater than 2 inches deep and 6 inches wide.	Restore filter surface, install erosion controls as needed			

Inspection and Maintenance Requirements for Media Filters (continued)

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Vault Structure (underground systems)						
Presettling (for attached bay/cell). (If separate presettling structure, follow requirements in Section D.2 or for Emerging Technologies, as appropriate)	A[2]	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.	Remove/dispose in accordance with state and federal regulations			
Pipes	A	Cracks wider than 0.5 inches at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Repair so that no cracks exist wider than 0.25 inch at the joint of the inlet/outlet pipe.			
Ladder	A	Ladder rungs damaged, missing, or misaligned.	Repair/replace			
Concrete	Inspect when vault cleaned	Riser, concrete walls, or joints cracked or leaking. Leveling bricks (if applicable) missing. Cracks greater than 0.5 inches wide or determined to be structurally unsound.	Repair			
Maintenance holes	A	Cannot be opened by one person. Locking bolts missing or damaged or less than ½ inch of thread.	Repair/replace			
	A	Buried.	Expose and restore to surface grade.			
Baffle(s)	A	Cracked, warped, or otherwise structurally unsound.	Repair/replace			
Air vents	A	Debris blocking 10 percent or more of vent.	Clean			

Inspection and Maintenance Requirements for Media Filters (continued)

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Filter Basin (above ground systems)						
Noxious weeds	M	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm	By law, noxious weeds (class A&B) must be removed bagged and disposed of as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Grass/ground cover	A	Residential area: mow when grass height reaches 18 inches. In other areas, match adjacent ground cover/terrain as long as there is no interference with facility function.	Mow to 4-inch height. Remove cuttings and dispose.			
Fence	A	Damage to gate/fence, posts out of plumb, or rails bent more than 6 inches.	Repair/replace			
	A	Brush/weeds along fence line.	Remove brush within 5 feet of fence (may want to mow more frequently than required inspections)			
	A	Erosion/settlement causing opening under the fence greater than 4 inches and 12-18 inches wide or openings along fence line greater than 8-inch diameter.	Repair			

Inspection and Maintenance Requirements for Media Filters (continued)

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Filter Basin (above ground systems) *(continued)*						
Dike/berm/ embankment	A	Settlement greater than 4 inches (relative to undisturbed sections of berm)	Restore to design height			
	A	Downstream face of berm or embankment wet, seeps or leaks evident	Plug holes. Contact geotechnical engineer ASAP.			
	A	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
	A	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and along side slopes. Note evidence of leakage through embankment.	Eliminate source of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket)			
Underdrains/Valves						
Valve exercised	A	Valve cannot be operated by one person. Valve rusted or not watertight.	Repair/replace			
Sediment	A	More than 1 inch of sediment in underdrain pipe	Remove and dispose			
Cleanouts						
	A	Sediment, debris, or vegetation blocking 1/2 of cleanout.	Remove/dispose in accordance with state and federal regulations.			
Rock Pad						
	A	Rock pad missing or damaged.	Repair/replace			

Inspection and Maintenance Requirements for Media Filters (continued)

Components	Required Inspection Frequency[1,2]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Inlet/Outlet						
Trash rack	B, W, E	Trash or other debris present on trash rack.	Remove/dispose			
	A	Bar screen damaged or missing	Replace			

[1] Inspection frequency
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

[2] Initial Inspection frequency:
Filters should be inspected every 6 months and after every large storm (e.g., >1 inch of precipitation in 24 hours) for the first year of operation. Frequency may be reduced if filter functions as designed for 1 year.

[3] Drawdown Tests:
Drawdown tests for the sand bed could be conducted, as needed, during the wet season. These tests can be conducted by allowing the filter to fill (or partially fill) during a storm event, then measuring the decline in water level over a 4-8 hour period. An inlet and an underdrain outlet valve would be necessary to conduct such a test.

D.5 Biofilters (Swales, Wet Swales, and Filter Strips)

Two types of biofilters are commonly used in stormwater treatment applications: biofiltration swales and vegetated filter strips. Both are land treatment systems that serve both conveyance and treatment functions. They are designed to remove pollutants by filtering stormwater through vegetation. They are designed to use vegetation and soil to capture pollutants in the stormwater which can then be degraded by microorganisms in the soil. They are usually planted with grass; however other vegetation such as emergent wetland species can be used depending on site conditions. Density and diversity of plant material has the added benefit of providing potential habitat for wildlife and beneficial insects.

Swales are broad, gently sloped channels that are designed to spread storm water flows over a wide, flat-bottomed channel to reduce flow velocity and promote contact with the vegetation. The longitudinal slope of a swale should be greater than 1 percent to convey flow, but not overly steep, to prevent erosion damage and to provide adequate time of contact between the storm water and vegetation. Slopes of between 2 and 4 percent are generally recommended for swales. If the slope is too great, check dams can be installed to slow down the flow.

Filter strips are broad vegetated surfaces that are designed to receive runoff in the form of sheet flow, rather than concentrated channel flow like swales. One disadvantage of filter strips is the difficulty in maintaining sheet flow due to the tendency for rills and channels to form as a result of unevenly distributed flow and excessive flow that stimulates erosion. Filter strips are generally most effective in locations where the contributing area is less than 5 acres and has slopes less than 10 percent.

Inspection and Maintenance Requirements for Biofiltration Swales, Wet Biofiltration Swales, and Filter Strips

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in facility)						
Trash/debris	M	Any visible accumulation of trash/debris should be removed at time of inspection. In general there should be no evidence of visual dumping.	Remove/dispose in accordance with state and federal regulations.			
Pollution	B, E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source.			
Noxious weeds	M	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm	By law, noxious weeds (class A&B) must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Basic Biofiltration Swale and Filter Strips						
Sediment	B, E	Accumulated sediment exceeds 2 inches over 25% of swale bottom or impedes vegetation growth over 25% of swale bottom.	Remove/dispose in accordance with state and federal regulations. Restore grass, protect from erosion until vegetation established.			

Inspection and Maintenance Requirements for Biofiltration Swales, Wet Biofiltration Swales, and Filter Strips (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Basic Biofiltration Swale and Filter Strips *(continued)*						
Grass/ vegetation	B	Grass height exceeds 10 inches.	Mow to 4-inch height (may want to mow more frequently than required inspections).			
Grass	M	Poor vegetation growth (<90 percent coverage) or weeds cover more than 10% of area.	Determine cause of poor vegetation growth and correct condition. Replant as necessary to obtain complete coverage.			
Vegetation	B	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.			
Flow characteristics	B	Standing/stagnant water, no visible water movement.	Check for downstream obstruction.			
Erosion/ scouring	B, E	Flow channelized, forming rills/gullies more than 2 inches deep.	Regrade swale bottom, re-install flow spreader, revegetate, protect from erosion until vegetation established.			
Wet Biofiltration Swale						
Sediment	B, E	Accumulated sediment exceeds 4 inches over 10% of swale bottom or impedes vegetation growth over 25% of swale bottom.	Remove/dispose in accordance with state and federal regulations. Restore grass, protect from erosion until vegetation established.			
Wetland vegetation	B	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed.			

Inspection and Maintenance Requirements for Biofiltration Swales, Wet Biofiltration Swales, and Filter Strips (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Flow Spreader						
Sediment	B, E	Ports/notches clogged or sediment trap filled.	Remove and dispose in accordance with state and federal regulations.			
Grade board/ baffle	B, E	Damaged or not level	Remove and reinstall to level position.			
Inlet/Outlet						
Trash rack (if present)	B, W, E	Trash or other debris present on trash rack.	Remove/dispose			
	A	Bar screen damaged or missing	Replace			
Inlet/Outlet Pipes and Areas	A	Sediment, debris, or vegetation blocking 1/2 capacity of inlet or outlet pipes or inlet or outlet areas.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Inlet/outlet piping damaged or broken and in need of repair.	Repair/replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

D.6 Infiltration Trenches, Drywells and Infiltration Basins

Infiltration trenches and other stormwater infiltration systems such as rock pockets, dry wells, and basins temporarily store stormwater so that it can gradually seep into the underlying soil and groundwater. Infiltration systems treat stormwater runoff by physically filtering particulates and particulate-bound pollutants as the water moves through the soil. In addition, pollutants can sorb onto the soil particles which aids in removing dissolved pollutants. Microbial degradation of some contaminants can also occur as water infiltrates through the soil.

Infiltration systems can also be used to reduce the rate of runoff from a site by removing the volume of runoff that would otherwise be discharged to the surface drainage system and allowing it to infiltrate into the ground.

Inspection and Maintenance Checklist/Report for Infiltration Trenches

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in facility)						
Trash/debris	A, W	Accumulated trash/debris impedes performance.	Remove/dispose in accordance with state and federal regulations.			
Pollution	A, W, E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulation. If possible, identify and control source.			
Drain rock	A, W	Water ponds at surface during storm events. Less than 90% of design infiltration rate.	Replace rock material			
Roof downspout (if present)	A, W	Splash pad missing or damaged.	Repair/replace			
	B, W	Leaves in downspout.	Remove/dispose			
All Surfaces Draining to Infiltration Trench (including roof drains, gutters, driveway drains, area drains, etc.)						
Trash/debris/sediment	A, W	Accumulation of trash, debris, or sediment.	Remove/dispose.			
Storage Sump						
Sediment	A	Accumulated material within 18 inches of the bottom of the outlet pipe or greater than designed sediment depth for sump.	Remove/dispose in accordance with state and federal regulations.			
Maintenance holes	A	Cannot be opened by one person. Locking bolts missing or damaged or less than ½ inch of thread.	Repair/replace			
	A	Buried.	Expose and restore to surface grade.			
	A	Cover missing.	Replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

Inspection and Maintenance Checklist/Report for Infiltration Basins

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in facility)						
Trash/debris/yard waste	M	Any visible accumulation of trash/debris should be removed at time of inspection. In general there should be no evidence of visual dumping.	Remove/dispose in accordance with state and federal regulations.			
Pollution	M, E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source.			
Noxious weeds	A	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm	By law, noxious weeds (class A&B) must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Insects	A	Wasps, hornets interfere with operations	Remove			
Beaver dams	A	Dam results in change or function of the facility.	Return facility to design function and modify design as necessary to discourage beaver use.			Once beavers are present all actions must follow State law permitting requirements.
Tree Growth and Hazard Trees	A	Tree growth does not allow maintenance access, interferes with maintenance activity, interferes with pond function or capacity, or if dead, diseased, or dying trees are identified.	Trim or remove trees. Remove dead, diseased or dying trees.			

Inspection and Maintenance Checklist/Report for Infiltration Basins (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Pond Areas						
Storage Area Infiltration	A	Water Not Infiltrating. Water does not drain within 48 hours (or design infiltration time) of end of storm event.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design			
Embankment and Emergency Spillway						
Spillway	A	Rock lining down to 1 layer of rock	Add rock to design conditions			
	A, W	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed			
Embankment	A	Downstream face wet, seeps or leaks evident	Plug holes. Contact geotechnical engineer ASAP.			
	A	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
	A	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and along side slopes. Note evidence of leakage through embankment. Any erosion observed on compacted berm embankment.	Eliminate source of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion)			
	A	Settlement greater than 4 inches in any portion of the structure or inspector determines dike/berm is unsound.	Restore to design height. A licensed civil engineer should be consulted to determine the source of the settlement.			

Inspection and Maintenance Checklist/Report for Infiltration Basins (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Embankment and Emergency Spillway *(continued)*						
Embankment (continued)	A,W	Piping. Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	Piping eliminated. Erosion potential resolved. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition).			
Tree/brush growth	A	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to berm failure.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm restoration.			
Presettling						
Presettling (for attached bay/cell). (If separate presettling structure, follow requirements in Section D.2 or for Emerging Technologies, as appropriate)	A	Sediment accumulation in presettling cell exceeds the depth of sediment zone plus 6 inches, usually in the first cell.	Remove/dispose in accordance with state and federal regulations			
Fence						
Damage	A	Damage to gate/fence, posts out of plumb, or rails bent more than 6 inches.	Repair/replace			

Inspection and Maintenance Checklist/Report for Infiltration Basins (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
***Fence** (continued)*						
Vegetation	A	Brush/weeds along fence line	Remove brush within 5 feet of fence			
Gaps	A	Erosion/settlement causing opening under the fence greater than 4 inches and 12-18 inches wide or openings along fence line greater than 8-inch-diameter.	Repair			
Pond Inlet/Outlet (if applicable)						
Trash rack	B, W, E	Trash or other debris present on trash rack.	Remove/dispose			
	A	Bar screen damaged, detached, or missing	Replace			
Inlet/Outlet Pipes	A	Sediment, debris, or vegetation blocking 1/2 capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Inlet/outlet piping damaged or broken and in need of repair.	Repair/replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release) as appropriate.

D.7 Ponds and Constructed Wetlands

Like vaults, ponds are storage facilities that can be designed as detention, water quality, or combined systems, except that ponds are above ground rather than underground facilities. Ponds are not commonly used in Seattle because above ground systems require more land to construct, which is usually not available in a highly urban setting. In addition to physical removal via sedimentation, ponds, particularly wet ponds also provide a suitable environment and adequate hydraulic residence time to promote biological and chemical reactions, which improves their ability to remove pollutants from urban runoff. In addition, aquatic plants that establish in the wet pool can also enhance sedimentation and promote pollutant uptake.

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General (at all locations in facility)						
Trash/debris/yard waste	A	Any visible accumulation of trash/debris should be removed at time of inspection. In general there should be no evidence of visual dumping.	Remove/dispose in accordance with state and federal regulations.			
Pollution	A, E	Any visible accumulation of oil, gas, paint, or other contaminant (includes concrete debris or slurry).	Remove/dispose in accordance with state and federal regulations. If possible, identify and control source.			
Noxious weeds	M (March – October)	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm	By law, noxious weeds (class A&B) must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Insects	A	Wasps, hornets interfere with operations	Remove			
Beaver dams	A	Dam results in change or function of the facility.	Return facility to design function and modify design as necessary to discourage beaver use.			Any action must be in compliance with State law and may require permits.
Tree Growth and Hazard Trees	A	Tree growth does not allow maintenance access, interferes with maintenance activity, interferes with pond function or capacity, or if dead, diseased, or dying trees are identified.	Trim or remove trees. Remove dead, diseased or dying trees.			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Dry Pond Areas						
Sediment	A	Accumulated sediment exceeds 10% of pond depth or 1 foot, whichever is less.	Remove/dispose in accordance with state and federal regulations.			
Grass/ground cover	2X June - October	Residential area: mow when grass height reaches 18 inches. In other areas, match adjacent ground cover/terrain as long as there is no interference with facility function.	Mulch mow to 4-inch height. Retain clippings to breakdown and feed soil. Remove cuttings and dispose.			
Liner (if present)	A	Liner is visible and has more than three ¼-inch holes in it.	Liner repaired or replaced. Liner is fully covered.			
Permanent Pool (wet pond) Areas						
Sediment	A	Accumulated sediment greater than depth of the sediment zone in forebay (typically 1 foot) plus 6 inches.	Remove/dispose in accordance with state and federal regulations.			
Water level	A, W	First cell is empty during wet season, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.			
Internal berm	A	Berm dividing cells are not level.	Level berm surface so that water flows evenly over entire length of berm.			
Liner (if present)	A	Liner is visible and has more than three ¼-inch holes in it.	Liner repaired or replaced. Liner is fully covered.			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Constructed Wetlands[2]						
Forebay	B	Sediment accumulation in presettling cell exceeds the depth of sediment zone plus 6 inches, usually in the first cell.	Sediment removed from pond bottom			
Wetland Cell	B	Wetland condition not sustained for at least 10 months of the year resulting in loss of 20% wetland vegetation.	Reevaluate design and function of facility.			
	B	Sediment accumulation inhibits growth of wetland plants or reduces wetland volume (greater than 1 foot of sediment accumulation).	Remove/dispose in accordance with state and federal regulations. Replant as needed.			
Embankment and Emergency Spillway						
Spillway	A	Rock lining down to one layer of rock	Add rock to design conditions			
Embankment	A	Downstream face wet, seeps or leaks evident.	Plug holes. Contact geotechnical engineer ASAP.			
	A	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
	A	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and along side slopes. Note evidence of leakage through embankment. Any erosion observed on compacted berm embankment.	Eliminate source of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket). If erosion is occurring on compacted berms, a licensed civil engineer should be consulted to resolve source of erosion.			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Embankment and Emergency Spillway *(continued)*						
Embankment (continued)	A	Settlement greater than 4 inches in any portion of the structure or inspector determines dike/berm is unsound.	Restore to design height. A licensed civil engineer should be consulted to determine the source of the settlement.			
	A,W	Piping. Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	Eliminate piping. Resolve erosion potential. (Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition)			
Tree/brush growth	A	Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to berm failure.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm restoration.			
Control Structure						
Sediment, trash, debris	A	Accumulated material within 18 inches of the bottom of the lowest pipe entering or exiting the structure or filling greater than 60 percent of the sump depth	Remove/dispose in accordance with state and federal regulations.			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Control Structure *(continued)*						
Structure (e.g., Riser)	A	Control structure is not securely attached.	Secure/repair			
	A	Structure is not in upright position (allow up to 10% from plumb).	Repair/reposition			
	A	Structure visibly damaged, crushed, broken, or otherwise deformed.	Repair/replace			
	A	Connections to outlet pipe are not watertight.	Repair/replace			
Overflow Pipe	A	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Clean			
Shear gate or Cleanout gate (exercise full open/close and inspect)	A	Gate cannot be operated by one person.	Lubricate, repair, or replace			
	A	Gate rusted on 50% of structure, not watertight, or missing.	Repair/replace			
	A	Chain or pull rod missing.	Replace			
	A	Not plumb within 10 percent.	Repair			
	A	Connection to outlet pipe rusted or leaking.	Repair/replace			
Maintenance hole	A	Cannot be opened by one person. Locking bolts missing or damaged or damaged or less than ½ inch of thread.	Repair/replace			
	A	Buried	Expose and restore to surface grade.			
	A	Cover missing.	Replace.			
Orifice plate(s)	A	Bent, rusted, out of place, obstructed or missing	Repair/clean/replace			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Control Structure *(continued)*						
Structural integrity	A	Ladder rungs damaged, missing, or misaligned	Repair/replace			
	A	Cracks wider than 0.5 inches and longer than 3 feet, missing leveling bricks (if applicable), or any evidence of soil entering.	Repair			
	A	Cracked or broken grate	Replace			
Outlet pipe	A	Submerged or partially submerged	Check for downstream obstruction			
	A	Sediment, debris, or vegetation blocking 1/2 capacity of pipe.	Remove/dispose in accordance with state and federal regulations.			
Shutoff Valve and/or Maintenance Drain						
Sediment	A	Vertical distance between sediment and drain pipe is less than 6 inches.	Remove/dispose in accordance with state and federal regulations.			
Valve exercised	A	Valve cannot be operated by one person. Valve rusted or not watertight.	Repair/replace			
Fence						
Damage	A	Damage to gate/fence, posts out of plumb, or rails bent more than 6 inches.	Repair/replace			
Vegetation	A	Brush/weeds along fence line	Remove brush within 5 feet of fence			
Gaps	A	Erosion/settlement causing opening under the fence greater than 4 inches and 12-18 inches wide or openings along fence line greater than 8-inch-diameter.	Repair			

Inspection and Maintenance Requirements for Ponds and Constructed Wetlands (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Inlet/Outlet						
Trash rack	B, W, E	Trash or other debris present on trash rack.	Remove/dispose.			
	A	Bar screen damaged, detached, or missing	Replace			
Inlet/Outlet Pipes	A	Sediment, debris, or vegetation blocking 1/2 capacity of inlet or outlet pipes.	Remove/dispose in accordance with state and federal regulations.			
	A	Pipe connections not secure.	Secure/repair			
	A	Inlet/outlet piping damaged or broken and in need of repair.	Repair/replace			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = Recommend that at least one inspection occur during the wet season, preferably after trees have lost their leaves; E = Recommend that additional inspections be performed as appropriate after major events (e.g., >1 inch of precipitation in 24 hours or environmental incident which causes contaminant release).

[2] Wetland Inspection Frequency:
Wetlands should be inspected at least twice per year during the first 3 years during both growing and non-growing seasons to observe plant species presence, abundance, and condition; bottom contours and water depths relative to plans; and sediment, outlet, and buffer conditions.

D.8 Energy Dissipaters

Energy dissipaters are devices that reduce the hydraulic energy in high velocity flows. Dissipaters are commonly made of rock or concrete and placed on the downstream end of culverts or sluiceways to prevent erosion, disperse flows, and prevent channeling or undercutting around the outlet. Inspection of dissipaters should occur annually and after major storm events. The inspections are to determine whether the structure is functioning properly and preventing damage from high energy flows.

Inspection and Maintenance Requirements for Energy Dissipaters

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Rock Pad						
Erosion	A	Only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil.	Replace/repair rock pad to meet design standards			
	A	Soil erosion in or adjacent to rock pad.	Repair/replace rock pad to meet design standards			
Dispersion Trench						
Sediment	A	Accumulated sediment exceeds 20% of the design depth.	Clean/flush pipe			
Discharge	A	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Redesign or rebuild trench to standards			
Perforations	A	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Clean/replace pipe			
Distributor	A	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Rebuild/redesign facility to standards			
Landslide hazard	A	Water in receiving area is causing or has potential of causing landslide problems.	Eliminate landslide hazard			
Manhole/Chamber (post, baffles, or sides)	A	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding 1 square foot which would make structure unsound.	Replace/repair structure to meet design standards			

[1] Inspection frequency:

A = Annually.

D.9 Bioretention Facilities (Cells and Planters)

Bioretention facilities (also known as rain gardens) include various designs using soil and plant complexes to manage stormwater. The healthy soil biology, soil structure and vegetation associated with bioretention facilities promote infiltration, storage, and slow release of stormwater flows to more closely mimic natural conditions. Bioretention facilities can be designed to meet flow control and basic, phosphorous and enhanced water quality treatment requirements.

Two types of bioretention facilities are included in this manual: bioretention cells and bioretention planters. Bioretention cells are shallow depressions with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Bioretention cells may or may not have an underdrain.

A bioretention planter is similar to a bioretention cell except that it is designed with an impervious bottom preventing infiltration to surrounding soil. Planters are most commonly configured as concrete reservoirs adjacent to building structures. After percolating through the bioretention soil, the water is discharged via an underdrain.

The long-term success of bioretention facilities is dependent upon proper maintenance. Regular use of soluble fertilizers, herbicides, and insecticides are not recommended because they degrade soil life and compact soils. If necessary to fertilize, the use of slow-release or organic products is suggested. The need for pesticides can be replaced by using integrated pest management techniques. A critical component of healthy soil maintenance is to supply organic matter by mulching with a leaf litter and arborist wood chip mulch. Mulch choices that are made of isolated parts of trees (i.e., beauty bark, fir bark mulch, washed play chips) can have a negative impact on the system.

Inspection and Maintenance Requirements for Bioretention (Swales and Planters)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Ponding Area (address applicable components)						
Concrete planter reservoir	A	Rot, cracks or failure in planter structure.	Repair/replace			
Earthen reservoir (embankments, dikes, berms, and side slopes)	B, S	Erosion (gullies/rills) greater than 2 inches deep around inlets, outlet, and along side slopes.	Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control blanket)			
	A, S	Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height			
	A, S	Downstream face of berm or embankment wet, seeps or leaks evident	Plug holes. Contact geotechnical engineer ASAP.			
	A	Any evidence of rodent holes or water piping around holes if facility acts as dam or berm	Eradicate rodents/repair holes (fill and compact)			
Rockery reservoir or walls	A	Rock walls are insecure.	Stabilize walls			
Sediment or debris accumulation	B	Accumulated sediment or debris to extent that swale infiltration rate reduced or surface storage capacity significantly impacted.	Remove excess sediment, bioretention soil, or debris. Identify and control the sediment source (if feasible)			
Basin inlet via surface flow	A, S	Soil is exposed or signs of erosion are visible.	Repair and control erosion sources			
Basin inlet via concentrated flow (e.g., curb cuts)	A, S	Sediment, vegetation, or debris partially or fully blocking inlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.			

Inspection and Maintenance Requirements for Bioretention (Swales and Planters) (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Ponding Area *(continued)*						
Basin Inlet splash block	B	Water splashes adjacent buildings.	Reconfigure/repair blocks			
	B	Water disrupts soil media.	Reconfigure/repair blocks			
Inlet/outlet pipe	A	Pipe is damaged.	Repair/replace			
	A	Pipe is clogged.	Remove roots or debris			
Outlet pipe/structure	A, S	Sediment, vegetation, or debris blocking 1/2 capacity of inlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.			
Trash rack	A, S	Trash or other debris present on trash rack.	Remove/dispose			
	A	Bar screen damaged or missing.	Replace			
Check dams and weirs	A, S	Sediment, vegetation, or debris blocking (or having the potential to block) flow control weir or orifice.	Clear the blockage. .			
	A, S	Erosion and/or undercutting is present.	Repair and take preventative measures to prevent future erosion and/or undercutting			
	A	Grade board or top of weir damaged or not level.	Restore to level position			
Overflow/ emergency spillway	A, S	Overflow spillway is 50% plugged with sediment or debris.	Remove/dispose			
	A, S	Native soil is exposed or other signs of erosion damage are present.	Repair erosion and stabilize surface of spillway			

Inspection and Maintenance Requirements for Bioretention (Swales and Planters) (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
***Ponding Area** (continued)*						
Bioretention soil	As Needed	Water remains in the basin 48 hours or longer after the end of a storm.	First, ensure that under drain (if present) is not clogged. If necessary, clear under drain. If this is not the problem, the bioretention soil is likely clogged. Remove upper 3 inches of soil and replace with imported bioretention soil. Identify sources of clogging and correct.			
Vegetation						
Bottom swale vegetation	M	Poor vegetation growth (<75% coverage) or weeds cover more than 15% of area).	Determine cause of poor vegetation growth and correct condition. Replant as necessary to obtain coverage.			
Upland slope vegetation	M	Poor vegetation growth (<75% coverage) or weeds cover more than 15% of area.	Determine cause of poor vegetation growth and correct condition. Replant as necessary to obtain coverage.			
Trees and shrubs	A	Large trees and shrubs interfere with operation of the basin or access for maintenance.	Prune or remove large trees and shrubs.			
	A	Standing dead vegetation is present.	Remove standing dead vegetation when covering greater than 10% of basin area. Replace dead vegetation annually or immediately if necessary to control erosion (e.g., on a steep slope). Determine cause or identify source for dead vegetation and address issue if possible.			

Inspection and Maintenance Requirements for Bioretention (Swales and Planters) (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Vegetation *(continued)*						
Mulch	A	Bare spots (without much cover) are present or mulch depth less than 2 inches.	Replenish mulch to cover bare spots and augment to minimum depth of 3 inches.			
Noxious weeds	Monthly (March - September)	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Weeds	M	Weeds are present.	Remove and dispose of weed material. Do not use herbicides or pesticides in order to protect soil microbes.			
Irrigation						
Irrigation system (if any)	Based on manu-facturer's instructions	Irrigation system present.	Follow manufacturer's instructions for operation and maintenance and troubleshooting			
Plant watering	Weekly or as required (May – September)	Plant establishment period (1-3 years).	Water weekly during periods of no rain to ensure plant establishment			

Inspection and Maintenance Requirements for Bioretention (Swales and Planters) (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Irrigation *(continued)*						
	As needed	Longer term period (3+ years).	Water during drought conditions or more often if necessary to maintain plant cover.			
General						
Spill response	As needed	Release of pollutants. Call to report any spill to the Seattle Operations Response Center at 206-386-1800.	Cleanup spills as soon as possible to prevent contamination of stormwater			
Spill prevention	Ongoing	Mechanical systems require the presence of potential contaminants.	Exercise spill prevention measures whenever handling or storing potential contaminants			
Safety -slopes	A	Erosion of sides causes slope to become a hazard.	Take actions to eliminate the hazard and stabilize slopes.			
Line of sight	A	Vegetation causes some visibility (line of sight) or driver safety issues.	Prune or remove if continual safety hazard.			
Pest Control						
Mosquitoes	B, S	Standing water remains for more than 3 days following storms.	Manually remove standing water. Identify the cause of the standing water and take appropriate actions to address the problem (improve drainage).			
Rodents	As required	Rodent holes present in facility	Fill and compact soil around the holes.			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); Q = Quarterly (four times per year); W = At least one inspection should occur during the wet season. For debris/clog related maintenance, this inspection should occur in the early fall, after deciduous trees have lost their leaves; S = Additional inspections should be performed after major storm events (this inspection may count toward other inspection requirements).

D.10 Permeable Pavement

Permeable pavement is the surface layer of a paving system which allows rainfall to percolate into an underlying soil or storage reservoir, where stormwater is stored and either infiltrated to underlying soil, or removed by an overflow drainage system. Permeable pavement can be designed to meet flow control requirements. Basic, phosphorous and enhanced water quality treatment requirements may also be met when the underlying soil meets the treatment soil requirements.

Two categories of permeable pavement systems are included in this manual: permeable pavement *facilities* and permeable pavement *surfaces*. *Facilities* typically have a thicker aggregate subbase than *surfaces* and may be designed to receive runoff from other areas. A facility may also be designed with underground detention by adding an underdrain with a flow restrictor. Permeable pavement *surfaces* help to maintain site perviousness and are assigned flow control credits.

The surface layer of a permeable pavement system is the wearing course. Categories of pervious paving wearing courses include porous asphalt concrete, porous cement concrete, interlocking concrete pavers, and open-celled paving grids with vegetation or gravel.

Inspection and Maintenance Requirements for Permeable Pavement

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Surface (address applicable components)						
Permeable pavements, all	A	Infiltration capacity of surface restricted due to clogging.	Remove sediment and debris. Maintenance methods include use of sidewalk sweepers equipped with vacuums, and brushes to remove surface debris during dry season. Use industrial pressure washer to restore permeability. Anticipate maintenance one to two times annually.			
	Ongoing	None. Maintenance to prevent clogging with fine sediment.	Prohibit use of sand and sealant application and protect from construction runoff.			
	A	None.	Remove sediment, debris, vegetation and any compacted materials such as trash.			
	As Needed	Utility cuts.	See utility restoration protocol on SPU NDS website at www.seattle.gov/util/naturalsystems.			
Inlet/outlet pipe	A	Pipe is damaged.	Repair/replace			
	A	Pipe is clogged.	Remove roots or debris			
Outlet pipe/structure	A, S	Sediment, vegetation, or debris blocking 1/2 capacity of inlet structure.	Clear the blockage. Identify the source of the blockage and take actions to prevent future blockages.			

Inspection and Maintenance Requirements for Permeable Pavement (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Surface (address applicable components) *(continued)*						
Permeable asphalt or cement concrete	A	Major cracks or trip hazards and concrete spalling and raveling.	Fill with patching mixes. Large cracks and settlement may require cutting and replacing the pavement section. Take appropriate precautions to prevent clogging of adjacent porous materials. See utility restoration protocol on SPU NDS website at www.seattle.gov/util/naturalsystems			
Interlocking concrete paver blocks or open-celled paving grid	A	Paver block or paving grid missing or damaged.	Replace or repair damaged paver block or paving grid			
	A	Settlement of surface.	May require resetting			
	A	Loss of void material between paver blocks.	Refill per manufacturer's recommendations.			
Interlocking concrete paver blocks or open-celled paving grid (continued)	Based on manu-facturer's instructions	Varied conditions.	Perform O&M per manufacturer's recommendations.			
Overflows and Emergency Spillways						
Obstructions / debris	B	Obstructions or debris block 50% or more of outlet structure.	Remove/dispose			
Erosion	B	Native soil is exposed or other signs of erosion damage are present.	Repair erosion and stabilize surface of spillway			

Inspection and Maintenance Requirements for Permeable Pavement (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Spill Prevention and Response						
Spills response	As needed	Release of pollutants. Call to report any spill to the Seattle Operations Response Center at 206-386-1800.	Cleanup spills as soon as possible to prevent contamination of stormwater			
Spill prevention	Ongoing	Mechanical systems require the presence of potential contaminants.	Exercise spill prevention measures whenever handling or storing potential contaminants			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = At least one inspection should occur during the wet season. For debris/clog related maintenance, this inspection should occur in the early fall, after deciduous trees have lost their leaves.

D.11 Green Roofs

Green roofs are areas of living vegetation installed on top of buildings to provide flow control via detention, attenuation, soil storage, and losses to interception, evaporation, and transpiration. Green roofs are also known as ecoroofs, green vegetated roofs, and roof gardens. Shallower soil installations (less than 6 inches) are referred to as “extensive” and deeper soil installations (6 inches or greater) are referred to as “intensive”.

A green roof consists of a system in which several materials are layered to achieve the desired vegetative cover, roof loading and drainage characteristics. Design components vary depending on the green roof type and site constraints, but typically include a waterproofing material, a drain system, a drainage layer, a separation fabric, a growth medium (soil), and vegetation.

Inspection and Maintenance Requirements for Green Roofs

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Soil / Growth Medium						
Growth medium	A[2]	Water does not permeate growth media (runs off soil surface).	Aerate or replace medium			
Growth medium	A	Growth medium thickness is less than design thickness (due to erosion and plant uptake)	Supplement growth medium to design thickness			
Fallen leaves/debris	B, W	Fallen leaves or debris are present.	Remove/dispose			
Erosion control measures	B[3]	Mulch, mat or other erosion control is damaged or depleted during plant establishment period.	Repair/replace erosion control measures until 90% vegetation coverage attained			
Erosion/scouring	A, W, S	Areas of potential erosion are visible.	Take steps to repair or prevent erosion. Stabilize with additional soil substrate/growth medium and additional plants.			
System Structural Components						
General	A	Structural components are present.	Inspect structural components for deterioration or failure. Repair/replace as necessary.			
Inlet pipe	B, S	Sediment, vegetation, or debris blocks 50% or more of inlet structure.	Clear blockage. Identify and correct any problems that led to blockage.			
	A	Inlet pipe is in poor conditions.	Repair/replace			
	A	Pipe is clogged.	Remove roots or debris.			
Vegetation						
Coverage	B	Vegetative coverage falls below 75% (unless design specifications stipulate less than 75% coverage).	Install more vegetation and erosion control measures until 90 percent coverage attained			

Inspection and Maintenance Requirements for Green Roof (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Vegetation *(continued)*						
Noxious weeds	Monthly (March – September)	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm.	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed, bagged and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Weeds	Q	Weeds are present.	Remove and dispose of weed material. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Plants	A	Dead vegetation is present.	Remove dead vegetation when covering greater than 10% of roof area. Replace dead vegetation annually or immediately if necessary to control erosion.			
Irrigation						
Irrigation system (if any)	Based on manu-facturer's instructions	Irrigation system present.	Follow manufacturer's instructions for operation and maintenance			

Inspection and Maintenance Requirements for Green Roof (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Irrigation *(continued)*						
Plant watering	Weekly (May – September)	Plant establishment period (1-3 years).	Water weekly during periods of no rain to ensure plant establishment			
	As needed	Longer term period (3+ years).	Water during drought conditions or more often if necessary to maintain plant cover			
Spill Prevention and Response						
Spill prevention	Ongoing	Mechanical systems require the presence of potential contaminants.	Exercise spill prevention measures whenever handling or storing potential contaminants			
Spills response	As needed	Release of pollutants. Call to report any spill to the Seattle Operations Response Center at 206-386-1800.	Cleanup spills as soon as possible to prevent contamination of stormwater			
Training and Documentation						
Training / written guidance	At startup	Training / written guidance required.	Provide property owners and tenants with proper training and a copy of the O&M Landscape and Maintenance Manual.			
Safety						
Access and safety	A	Egress/ingress routes and fall protection.	Maintain egress and ingress routes to design standards and fire codes. Ensure appropriate fall protection.			
Aesthetic						
Aesthetics	A	Damage/vandalism/debris accumulation.	Restore roof to original aesthetic conditions			

Inspection and Maintenance Requirements for Green Roof (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Aesthetics *(continued)*						
Grass/vegetation	A	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g., remove/replace plants, amend soil, etc.)			
Pest Control						
Mosquitoes	B	Standing water remains for more than 3 days following storms.	Manually remove standing water. Identify the cause of the standing water and take appropriate actions to address the problem (improve drainage).			
Rodents	As required	Rodent holes present in facility	Fill and compact soil around the holes.			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); W = At least one inspection should occur during the wet season. For debris/clog related maintenance, this inspection should occur in the early fall, after deciduous trees have lost their leaves.

[2] Inspection should occur during storm event.

[2] Inspection should occur during plant establishment period (typically first 2 years).

D.12 Cisterns

Cisterns are tanks used for the capture, detention and/or harvest of stormwater runoff. This manual includes two related flow control BMPs: detention cisterns and rainwater harvesting.

Detention cisterns are aboveground tanks used for the capture and detention of stormwater runoff. Runoff from roof downspouts and other impervious surfaces can be routed to cisterns for detention and slow release via a low flow orifice to an approved discharge point.

Rainwater harvesting is the capture and storage of rainwater for beneficial use. Cisterns for rainwater harvesting may be above- or belowground. Roof runoff may be routed to cisterns for storage and nonpotable uses such as irrigation, toilet flushing and cold water laundry. Unlike detention cisterns, harvesting systems include rainwater treatment equipment and a delivery and distribution system.

Inspection and Maintenance Requirements for Cisterns

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Collection Facilities						
Roof	B	Debris has accumulated.	Remove debris			
Gutter	B	Debris has accumulated.	Clean gutters (the most critical cleaning is in mid- to late-spring to flush the pollen deposits from surrounding trees)			
Screens at the top of downspout and cistern inlet	A	Screen has deteriorated.	Replace			
	Monthly (October – April), S	None. Preventative maintenance.	Clear screen of any accumulated debris			
Overflow pipe	B	Pipe is damaged.	Repair/replace			
	B	Pipe is clogged.	Remove debris			
Cistern	A	Debris has accumulated at bottom of tank.	Remove debris			
Low flow orifice (detention cistern)	Monthly (October – April), S	None. Preventative maintenance.	Clean low flow orifice			
Delivery and distribution system (harvesting)	Varies	Ongoing maintenance (e.g., backflow prevention inspections, valve schedules and operation, backup and cross connection, and seasonal startup and shutdown and freeze protection)	Follow manufacturer's instructions for operation and maintenance			
Rainwater treatment and use equipment (harvesting)	Varies	Ongoing maintenance (e.g., replacing and/or cleaning filters, removing sediment and other pollutants from storage systems)	Follow manufacturer's instructions for operation and maintenance			

Inspection and Maintenance Requirements for Cistern (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
Training and Documentation						
Training / written guidance	At startup	Training / written guidance is required for proper operation and maintenance.	Provide property owners and tenants with proper training and a copy of the O&M manual			
Safety						
Access and safety	Ongoing	Access to cistern required for maintenance or cleaning.	Any cistern detention systems opening that could allow the entry of people must be marked: "DANGER—CONFINED SPACE"			
Pest Control						
Mosquitoes	B	Standing water remains for more than 3 days following storms.	Ensure all inlets, overflows, and other openings are protected with mosquito screens			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); S = Additional inspections should be performed after major storm events (this inspection may count toward other inspection requirements).

D.13 Compost Amended Soil

All areas disturbed during a project must meet post construction soil quality and depth requirements. These requirements may be achieved by compost amending site soils. The most important maintenance requirement is that organic matter be replenished by leaving leaf litter and grass clippings on-site, or by adding compost and mulch regularly. This BMP is designed to reduce use of irrigation, fertilizers, herbicides, and pesticides. Rather than continuing to implement formerly established practices, these activities should be adjusted where possible. In particular, regular use of soluble fertilizers, herbicides, and insecticides degrades soil life and compacts soil. Instead, fertilization can be reduced by using slow-release or organic products, and the need for pesticides can be reduced by using integrated pest management techniques.

Since compost amended soils are not a stormwater facility specifically designed to achieve a given stormwater performance threshold, the maintenance practices outlined in the following tables are recommendations, not requirements.

Inspection and Maintenance Recommendations for Compost Amended Soil

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General Facility RECOMMENDATIONS						
Soil media (maintain high organic soil content)	A	Vegetation not fully covering ground surface.	Re-mulch landscape beds with 3 inches of mulch until the vegetation fully closes over the ground surface			
	Ongoing	None. Preventative maintenance.	Return leaf fall and shredded woody materials from the landscape to the site as mulch			
	Ongoing	None. Preventative maintenance.	On turf areas, “grasscycle” (mulch-mow or leave the clippings) to build turf health			
	Ongoing	None. Preventative maintenance.	Avoiding use of pesticides (bug and weed killers) like “weed & feed,” which damage the soil life			
	A	None. Preventative maintenance.	Where fertilization is needed (mainly turf and annual flower beds), a moderate fertilization program which relies on compost, natural fertilizers or slow-release synthetic balanced fertilizers			

Inspection and Maintenance Recommendations for Compost Amended Soil (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General Facility RECOMMENDATIONS *(continued)*						
Compaction	A [2]	Soils become waterlogged, do not appear to be infiltrating.	To remediate, aerate soil, till or further amend soil. If drainage is still slow, consider investigating alternative causes (e.g., high wet-season groundwater levels, low permeability soils). Also consider land use and protection from compacting activities. If areas are turf, aerate compacted areas and topdress them with ¼-½ inch of compost to renovate them.			
Erosion/scouring	A, W, S	Areas of potential erosion are visible.	Take steps to repair or prevent erosion. Identify and address the causes of erosion.			
Grass/vegetation	A	Less than 75% of planted vegetation is healthy with a generally good appearance.	Take appropriate maintenance actions (e.g., remove/replace plants)			
Noxious weeds	Monthly (March – September)	Listed noxious vegetation is present. See King County noxious weed list: http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm.	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed, bagged, and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			

Inspection and Maintenance Recommendations for Compost Amended Soil (continued)

Components	Required Inspection Frequency[1]	Condition when Maintenance Required	Action Required	Satisfactory	Unsatisfactory	Comments
General Facility RECOMMENDATIONS *(continued)*						
Weeds	M	Weeds are present.	Remove and dispose of weed material. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.			
Pest Control						
Mosquitoes	B	Standing water remains for more than 3 days following storms.	Manually remove standing water. Identify the cause of the standing water and take appropriate actions to address the problem (improve drainage).			
Rodents	As required	Rodent holes present in facility	Fill and compact soil around the holes.			

[1] Inspection frequency:
A = Annually; B = Biannually (twice per year); Q = Quarterly (four times per year); W = At least one inspection should occur during the wet season. For debris/clog related maintenance, this inspection should occur in the early fall, after deciduous trees have lost their leaves; S = Additional inspections should be performed after major storm events (this inspection may count toward other inspection requirements).

[2] Inspection should occur during storm event.

D.14 Trees

Trees, whether natural or introduced to a site, provide flow control via interception, transpiration, and increased infiltration. In addition, trees improve air quality, reduce the heat island effect of urban development, remove certain pollutants, and provide habitat.

Components	Required Inspection Frequency	Condition when Maintenance Required	Action Required
Tree	As needed	Dead, damaged or declining	Replace per planting plan or acceptable substitute.

D.15 Operations and Maintenance Requirements for Single Family Parcels

Smaller scale systems warrant more simplified maintenance requirements. The following tables identify the minimum requirements for maintenance on single family parcels. Maintenance activities shall occur on an as needed basis.

Facilities included are the Green Stormwater Infrastructure facilities, bioretention, permeable pavement, green roofs, cisterns, and trees.

Inspection and Maintenance Requirements on Single Family Residential Parcels for Bioretention

What to Look For	What to Do	Why
Hardscape Requirements		
Clogged inlets, outlets, or under drains pipes	Remove sediment and debris from catch basins, trench drains, curb inlets, and pipes to overflow/ outflow.	Restricted flows from sediment, debris or trash can cause backups and flooding and reduce infiltration.
Cracked drain pipes	Repair / seal cracks. Replace when repair is insufficient.	Crack can expand and reduce the effectiveness of the stormwater facility.
Cracked Concrete Planter	Repair or replace rot, cracks of failures in planter structure.	Ensures water does not discharge to undesired locations.
Soil / filter layer/ mulch Requirements		
Check dams and berms	Maintain design height of check dams and berms by removing sediment build up and/or correcting erosion problems.	Sediment build up can reduce stormwater holding capacity and increase the negative impact of stormwater.
Erosion and Gullies	Take measures to prevent future erosion and/or undercutting. May include replacement of splash block or inlet gravel/rock or stabilizing slopes/banks. Gullies can be filled, lightly compacted and replanted.	Sediment from erosion can clog pours in the swale bottom and reduce infiltration, which reduce system function and can potentially causing ponding.
Ponding	Remove sediment buildup in surface of soil media to restore designed infiltration, this may require removing and replacement of the upper 3 inches of soil.	Ponding reduces capacity of the swale and can create mosquito habitat if present for over 72 hours during breeding season.
Vegetation Requirements		
Proper care	Provide irrigation as needed during establishment period (approximately 3 years post planting). Low flow systems under mulch layer maximize irrigation efficiency.	Even known drought tolerant plants can require additional watering until sufficiently deep roots have developed. Having irrigation under mulch reduces evaporation, and keeps root zone cool, thereby reducing stress to plants.
	Do not apply any fertilizer, herbicides, or pesticides in or around bioretention facilities.	Bioretention systems depend on soil microbes to provide plant nutrients and enhance infiltration; most landscape products are toxic to soil microbe life.
	Recommend maintaining a 3 inch depth of mulch.	A mulch layer is effective at helping to prevent weed seeds from establishing. Mulch is also the primary energy source for many soil microbe which help maintain the health of the system.

Inspection and Maintenance Requirements on Single Family Residential Parcels for Bioretention (continued)

What to Look For	What to Do	Why
Proper care (continued)	Avoid bark based mulch, 'Beauty Bark' and 'Washed play chips'.	Soil microbes have diverse needs, mulch made up of one component of a tree selects for only organisms that can breakdown that part of the tree, resulting in an unbalanced, unhealthy soil ecosystem. Arborist woodchip mulch and compost can feed a diverse range of beneficial organisms. Variable particle sizes can also retain more water during the growing season by refracting more of the suns energy than fine, uniform, screened mulches.
Dead, damaged or declining vegetation	Replace per planting plan, or acceptable substitute	Bioretention systems use vegetation to slow and filter pollutants and sediment, as well as evapotranspire stormwater. Struggling vegetation provides inadequate treatment and must be replaced.
Weeds and volunteer vegetation	Recommend manually removal of weeds, and not using herbicide. Manual maintenance can be done by mowing, line trim or out competing with desired vegetation.	Weeds compete for moisture, and nutrients, displacing the desired species. Herbicide can destroy microbes in the grass cells, subsurface soils reducing treatment potential of system.
Poisonous vegetation or noxious weeds	Must be removed by mechanical means	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed, bagged, and disposed as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds.

Inspection and Maintenance Requirements on Single Family Residential Parcels for Permeable Pavements

What to Look For	What to Do	Why
Hardscape Requirements		
Proper Care	Sweep leaf litter and sediment to prevent surface clogging and ponding	Sediment and debris can clog the facility, destroying the benefits of the investment.
	Recommend vacuum sweeping annually to maintain infiltration	Preventative maintenance can extend operational life of system.
	Maintain aggregate depth in pavers open spaces close to the original design	Aggregate is an integral component to some permeable paver materials structural integrity.
	Do not use sealant applications	Sealant will clog the facility, which in turn will require facility replacement.
	Protect from sediment sources such as construction runoff or landscaping activities.	Sediment and debris can clog the facility, destroying the benefits of the investment
Clogged surface	Vacuum sweep or power wash as needed (do not use surfactant).	Retaining designed infiltration rate is crucial to meeting site drainage needs.
Cracked surface, uneven pavers or moving edge restraints	Repair or replace per design specifications to eliminate tripping hazards. Repair may include filling limited areas with patching mixes.	Reduce tripping hazard, ease maintenance and retain adequate filter medium.
Vegetation Requirements		
Significant bare soil in vegetated paver materials	Replace with specified sand, gravel and topsoil mix and vegetation according to approved plans	Vegetated Open-Celled Paving Grids need vegetation to capture suspended solids in stormwater and root associated microbes to breakdown pollutants in the runoff.
Weeds and volunteer vegetation	Recommend manually removal of weeds, and not using herbicide. Manual maintenance can be done by mowing, line trim or out competing with desired vegetation.	Weeds compete for moisture, and nutrients, displacing the desired species. Herbicide can destroy microbes in the grass cells, subsurface soils reducing treatment potential of system.
Poisonous vegetation or noxious weeds	Must be removed by mechanical means.	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed and disposed of immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds.
Large shrub or trees	Recommend promotion of deeper rooting to minimize surface root damage to subsurface structural components.	Infrequent and deep watering and careful plant selection can reduce the risk of roots damaging the pavement.

Inspection and Maintenance Requirements on Single Family Residential Parcels for Green Roofs

What to Look For	What to Do	Why
Hardscape Requirements		
Clogged drains	Inspect drains and remove any sediment and debris blockage.	Reduces risk of flooding and leakage
Leaks, tears or perforation in the membrane	Repair or replace membrane.	Reduces risk of flooding and leakage
Soil/ filter layer/ Mulch Requirements		
Erosion and Gullies	Take measures to prevent future erosion and/or undercutting. Gullies can be filled, lightly compacted and replanted.	Erosion can result in compromised system performance.
Ponding	Check for clogged drains or source of impeded drainage.	Ponding can create mosquito habitat if present for over 72 hours during breeding season and suggests system is not functioning properly.
Vegetation Requirements		
Dead, damaged or declining vegetation	Replace per original planting plan, or acceptable substitute.	The leaf surface intercepts storm water and evaporates water through wind; a healthy root system can absorb water and transpire. Vegetation also stabilizes soil media from erosion. Struggling vegetation must be replaced to maximize effectiveness.
Wilted, yellow, or drooping drought stressed vegetation	Recommend testing irrigation system, confirm function. Systems should be irrigated during establishment period and drought conditions.	Even drought tolerant plants require additional watering until sufficiently deep roots have developed.
Indication of pesticide use	Recommend no application of fertilizer, herbicides, or pesticides on the vegetated roof.	Use of fertilizer, herbicide, or pesticide products adds pollutants to the clean water.
Weeds and volunteer vegetation	Recommend manually removal of weeds, and not using herbicide.	Weeds compete for moisture, and nutrients, displacing the desired species. Herbicide can destroy microbes in the grass cells, subsurface soils reducing treatment potential of system.
Poisonous vegetation or noxious weeds	Must be removed by mechanical means.	By law, noxious weeds (class A&B http://www.dnr.metrokc.gov/wlr/lands/weeds/laws.htm) must be removed, bagged, and disposed of as garbage immediately. Reasonable attempts must be made to remove and dispose of class C noxious weeds

Inspection and Maintenance Requirements on Single Family Residential Parcels for Rainwater Harvesting

What to Look For	What to Do	Why
Clogged drains and gutter	Inspect and remove any sediment and debris blockage.	Maximize harvest volume and stormwater benefit from the investment.
Full tank	Empty tank before wet season (September 30th). Can close valve at end of wet season (May 1st).	Maintain stormwater benefit from the investment
Significant debris in tank	Remove debris	Maximize harvest volume and stormwater benefit from the investment
Disassemble and inspect low flow orifice	Inspect and clean low flow orifice.	Preventive maintenance can extend operational life of the system and ensure designed stormwater benefit achieved.
Inspect screen/filter system for sediment or debris	Clean or replace system elements.	Maintains clear flow path

D.16 Schedule of Continuing Responsibility for Green Stormwater Infrastructure in the Public Right-of-Way

Vegetated facilities require a plant establishment period prior to the system being complete. For vegetated green stormwater infrastructure drainage control facilities which the City allows to be placed by a project proponent within the City of Seattle Right-of-Way under a permit issued by the City or by City agreement, Seattle considers the plant establishment period to be the responsibility of the project proponent. Seattle intends to enforce the vegetation establishment responsibilities defined below. This vegetation establishment period includes maintaining, repairing, and/or replacing the associated vegetative components; any structural or functional repairs; and the general maintenance of the facility. In addition, for bioretention facilities the project proponent shall maintain the TESC for a minimum of 3 months following the date of planting completion. The project proponent is also responsible for reporting to the City on the condition of the facility on a scheduled basis over the warranty period, as outlined in the table below. The reporting form and where to send the completed form can be found on the SPU website (http://www.seattle.gov/util/greeninfrastructure). Seattle Public Utilities reserves the right to inspect the facility to verify that the information in the reports is accurate. The warranty period is 2 years and begins on the date of final acceptance. The City reserves the right to perform any work necessary to correct deficiencies in the facility should the project proponent fail to perform the work after having been given notice. The City reserves the right to and intends to seek reimbursement from the project proponent for all costs associated with performance of the work to bring the facility into compliance with the permit or agreement conditions.

Schedule of Warranty Period Reports for Green Stormwater Infrastructure in the Public Right-of-Way

Beginning of Warranty Period	Project proponent shall submit contact information for the representative responsible for ensuring maintenance of facility. For bioretention facilities, a landscape management plan is submitted detailing how the maintenance requirements will be met. This applies only to non-single family residential projects.
10-month establishment report and inspection	Project proponent shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and /or observations. *If the facility does not pass SPU inspection, SPU will submit a letter to the* project proponent *describing necessary remedial actions to be performed. This letter shall serve as final notice to the* project proponent *and its sureties that failure to correct the deficiencies in accordance with the permit or agreement conditions and prior to the end of the warranty period will result in the City performing the work and seeking reimbursement from the* project proponent *for all costs associated with the City performing the work.*
18-month establishment report and inspection	Project proponent shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and /or observations.
24-month establishment report and inspection	Project proponent shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and /or observations. *At this time, if all inspections have passed, the warranty period ends and the facility is turned over to SPU for long-term maintenance.*

Appendix E –

City of Seattle Modified Procedure for Conducting a Pilot Infiltration Test

Appendix E - City of Seattle Modified Procedure for Conducting a Pilot Infiltration Test

The Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better measure infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale double ring infiltrometer or "stove-pipe" infiltration tests. It is not a standard test but rather a practical field procedure based on the methods recommended by Ecology's Technical Advisory Committee. Correction factors must be applied to the infiltration rate measured using PIT to establish a design infiltration rate for BMP sizing.

For infiltration basins, there shall be one test pit per 5,000 square feet of basin infiltrating surface with a minimum of two per basin, regardless of basin size. For bioretention facilities and permeable pavement facilities, there shall be one test pit per 5,000 square feet of contributing area. For infiltration trenches, there shall be one test pit per 50 feet of trench length. For drywells, there shall be at least one test pit per well.

Prepare detailed logs for each test pit and a map showing the location of the test pits. Logs must include the depth, depth to water, evidence of seasonal high groundwater elevation, existing ground surface elevation, proposed facility bottom elevation, and presence of stratification that may impact the infiltration design.

PIT test reports shall be stamped by a Professional Engineer or prepared by an on-site wastewater treatment designer licensed with the State of Washington.

E.1 Infiltration Test

- Excavate the test pit to the depth of the bottom of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test.
- The size of the bottom of the test pit should be as close to the size of the planned infiltration facility as possible, but not less than 2 feet by 2 feet. Where water availability is a problem, smaller areas may be considered as determined by the site professional.
- Accurately document the size and geometry of the test pit.
- Install a device capable of measuring the water level in the pit during the test. This may be a pressure transducer (automatic measurements) or a vertical measuring rod (minimum 5 feet long) marked in half-inch increments in the center of the pit bottom (manual measurements).

- Use a rigid 6-inch-diameter pipe with a splash plate or some other device on the bottom of the pit to reduce side-wall erosion and excessive disturbance of the pit bottom. Excessive erosion and disturbance may result in clogging and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth should not exceed the proposed maximum depth of water expected in the completed facility.

Every 15 to 30 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod. This can best be accomplished with an in-flow meter. It can also be accomplished by timing how long it takes to fill a known volume such as a 5 gallon bucket.

Add water to the pit until 1 hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level (usually 17 hours).

After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour using the pressure transducer or measuring rod, until the pit is empty.

E.2 Data Analysis

Calculate and record the infiltration rate in inches per hour until 1 hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

E.3 Apply Correction Factor

The infiltration rate obtained from the PIT test shall be considered to be a short-term rate. This “short-term” rate must be reduced through correction factors to account for site variability and number of tests conducted, degree of long-term maintenance and influent pretreatment/control, and potential for long-term clogging due to siltation and bio-buildup. The corrected infiltration rate is considered the “long-term” or “design” infiltration rate and is used for all BMP sizing calculations.

One exception to the requirement for a correction factor applies to bioretention facilities. Specifically, when imported bioretention soil is used, no correction factor is required for the infiltration rate of the underlying native soil.

A minimum infiltration rate correction factor of 2.0 is required for all facilities designed using the PIT method. Correction factors greater than 2.0 should be considered for situations where long-term maintenance will be difficult to implement, where little or no pretreatment is anticipated, or where site conditions are highly variable or uncertain. These situations require the use of best professional judgment by the site engineer and the approval by the City of Seattle. The typical range of correction factors to account for these issues, based on Ecology's guidance, is summarized in Table E-1. **In no case shall the design infiltration rate exceed 10 inches per hour.**

Table E-1. Correction Factors to be Used With In-Situ Infiltration Measurements to Estimate Long-Term Design Infiltration Rates.

Issue	Partial Correction Factor
Site variability and number of locations tested	CFv = 1.5 to 6
Degree of long-term maintenance to prevent siltation and bio-buildup	CFm = 2 to 6
Degree of influent control to prevent siltation and bio-buildup	CFi = 2 to 6

Total Correction Factor (CF) = $CF_v + CF_m + CF_i$

The following discussions are to provide assistance in determining the partial correction factors that may apply.

Site variability and number of locations tested – The number of locations tested must be capable of producing a picture of the subsurface conditions that fully represents the conditions throughout the facility site. The partial correction factor used for this issue depends on the level of uncertainty that adverse subsurface conditions may occur. If the range of uncertainty is low—for example, conditions are known to be uniform through previous exploration and site geological factors—one pilot infiltration test may be adequate to justify a partial correction factor at the low end of the range. If the level of uncertainty is high, a partial correction factor near the high end of the range may be appropriate. This might be the case where the site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high. A partial correction factor near the high end of the range could be assigned where conditions have a more typical variability, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Degree of long-term maintenance to prevent siltation and bio-buildup – The standard of comparison here is the long-term maintenance requirements provided in Appendix D with these requirements would be justification to use a partial correction factor at the low end of the range. If there is a high degree of uncertainty that long-term maintenance will be carried out consistently, or if the

maintenance plan is poorly defined, a partial correction factor near the high end of the range may be justified.

Degree of influent control to prevent siltation and bio-buildup – A partial correction factor near the high end of the range may be justified under the following circumstances:

- If the infiltration facility is located in a shady area where moss buildup or litter fall buildup from the surrounding vegetation is likely and cannot be easily controlled through long-term maintenance
- If there is minimal pre-treatment, and the influent is likely to contain moderately high TSS levels.

If influent into the facility can be well controlled such that the planned long-term maintenance can easily control siltation and biomass buildup, then a partial correction factor near the low end of the range may be justified.

The determination of long-term design infiltration rates from in-situ infiltration test data involves a considerable amount of engineering judgment. Therefore, when reviewing or determining the final long-term design infiltration rate, the local jurisdictional authority should consider the results of both textural analyses and in-situ infiltration tests results when available.

Example:

The area of the bottom of the test pit is 8.5 feet by 11.5 feet.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes, the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or an average of (9.8 + 12.3) / 2 = 11.1 inches per hour.

Applying at least the minimum correction factor of 2.0 (example only) the design long-term infiltration rate becomes 5.6 inches per hour, anticipating adequate maintenance and pre-treatment.

Appendix F –

Geotextile Specifications

Appendix F - Geotextile Specifications

F.1 Applications

1. For sand filter drain strip between the sand and the drain rock or gravel layers specify Geotextile Properties for Underground Drainage, moderate survivability, Class A, from Tables F.1 and F.2 in the Geotextile Specifications.

2. For sand filter matting located immediately above the impermeable liner and below the drains, the function of the geotextile is to protect the impermeable liner by acting as a cushion. The specification provided below in Table F.3 should be used to specify survivability properties for the liner protection application. Table F.2, Class C should be used for filtration properties. Only nonwoven geotextiles are appropriate for the liner protection application.

3. For an infiltration drain specify Geotextile for Underground Drainage, low survivability, Class C, from Tables F.1 and F.2 in the Geotextile Specifications.

4. For a sand bed cover a geotextile fabric is placed exposed on top of the sand layer to trap debris brought in by the storm water and to protect the sand, facilitating easy cleaning of the surface of the sand layer. However, a geotextile is not the best product for this application. A polyethylene or polypropylene geonet would be better. The geonet material should have high UV resistance (90 percent or more strength retained after 500 hours in the weatherometer, ASTM D4355), and high permittivity (ASTM D4491, 0.8 sec. -1 or more) and percent open area (CWO-22125, 10 percent or more). Tensile strength should be on the order of 200 lbs grab (ASTM D4632) or more.

Courtesy of Tony Allen, Geotechnical Engineer-WSDOT.

Reference for Tables F.1 and F.2: Section 9-33.2 “Geotextile Properties,” 2006 Standard Specifications for Road, Bridge, and Municipal Construction.

Table F.1. Geotextile Properties for Underground Drainage: Geotextile Property Requirements[1]

Geotextile Property	Test Method	Low Survivability Woven / Nonwoven	Moderate Survivability Woven / Nonwoven
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	180 lbs / 115 lbs min.	250 lbs / 160 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	<50% / >50%	<50% / >50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	160 lbs / 100 lbs min.	220 lbs / 140 lbs min.
Puncture Resistance	ASTM D4833	67 lbs / 40 lbs min.	80 lbs / 50 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	67 lbs / 40 lbs min.	80 lbs / 50 lbs min.
Ultraviolet (UV) Radiation Stability	ASTM D4355	50% strength retained min., after 500 hrs. in weatherometer	50% strength retained min., after 500 hrs. in weatherometer

[1] All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

Table F.2. Geotextile for Underground Drainage Filtration Properties: Geotextile Property Requirements[1]

Geotextile Property	Test Method	Class A	Class B	Class C
AOS[2]	ASTM D4751	.43 mm max. (#40 sieve)	.25 mm max. (#60 sieve)	.18 mm max. (#80 sieve)
Water Permitivity	ASTM D4491	.5 sec – 1 min.	.4 sec – 1 min.	.3 sec – 1 min.

[1] All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

[2] Apparent Opening Size (measure of diameter of the pores in the geotextile)

Table F.3. Geotextile Strength Properties for Impermeable Liner Protection

Geotextile Property	Test Method	Geotextile Property Requirements[1]
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	250 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	>50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	220 lbs min.
Puncture Resistance	ASTM D4833	125 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	90 lbs min.
Ultraviolet (UV) Radiation	ASTM D4355	50% strength stability retained min., after 500 hrs. in weatherometer

[1] All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).